Appendix B
Plan Formulation

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

MAY - 7 2013

MEMORANDUM FOR DIRECTOR OF CIVIL WORKS

SUBJECT: Sutter Basin, California – Deviation from the National Economic Development Plan

I am responding to the Army Corps of Engineers (Corps) memorandum dated March 18, 2013, which requests an exception to the policy that requires decision documents to recommend the National Economic Development (NED) Plan. The exception would allow the subject draft feasibility report and draft environmental impact statement to tentatively recommend a Locally Preferred Plan (LPP) for flood risk management improvements. The request indicates that the Sutter Butte Flood Control Agency and the Central Valley Flood Protection Board, as the non-Federal sponsors, support the LPP in lieu of the NED Plan in order to comply with California Government Code requirements for a 200-year level of protection for urban and urbanizing areas by 2025.

Based on the materials provided, the LPP would reduce the vulnerability of a larger population and additional critical infrastructure, reduce economic flood risks to a greater extent, and provide more evacuation routes relative to the NED Plan. The LPP would cost about $290,000,000 more than the NED Plan. As proposed, the non-Federal sponsors would be responsible for the entire extra cost, which would increase the non-Federal cost share from about $148,000,000 for the NED Plan to about $438,000,000 for the LPP. The Federal cost share of initial construction, estimated at $275,000,000, would remain the same for the NED Plan and the LPP.

In addition to the request for an exception, the Corps provided responses on April 17, 2013, to questions my staff raised about the study and the two plans. The responses resolved all but three of those concerns. First, significant population growth during the 50-year period of analysis appears likely and must be explicitly considered in evaluating the public safety aspects of the final alternatives and measures for managing the respective residual risks. Second, the effect of induced development on the public safety aspects of the final alternatives and the residual risks must be assessed. If a reasonable estimate of induced development cannot be achieved, then the analyses should assume full development of areas designated as potentially developable. Areas with temporary restrictions on development should be considered potentially developable unless the Corps can demonstrate that the temporary restrictions would become permanent. Third, the effects of alternatives and their respective induced development and population growth on natural floodplain functions, including the ecological and hydrologic functions, must be assessed.

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After reviewing the materials provided, I have decided to grant the requested policy exception, subject to the Corps incorporating the information discussed above into the final decision documents. The documents should be explicit about compliance with EO 11988, particularly the determination of practicable alternatives. The draft feasibility report and draft environmental impact statement may tentatively select the LPP and be released for public review. I concur that the added cost of the LPP relative to the NED Plan, currently estimated at $290,000,000, would be a 100 percent non-Federal cost, with the remainder of the first cost shared 65 percent Federal, 35 percent non-Federal consistent with current policy.

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

18 FEB '11

CECW-P

MEMORANDUM FOR MAJOR SUBORDINATE COMMANDS

SUBJECT: Civil Works Program - National Pilot Program: Initial Pilot Study Selection

CORE,

1. Reference memorandum dated 3 February 2011, subject: Civil Works Program - Pilot Study Implementation. The Pilot Program is intended to validate concepts of a new pre-authorization (planning) study paradigm that shortens the timeframe for completion of a planning study, while maintaining the quality and integrity of the analyses. The purpose of this memorandum is to announce the selection of the initial pilot studies for the National Pilot Program.

2. In the referenced memorandum input on three potential pilot studies was requested: Central Everglades, FL; Jordan Creek (Springfield), MO; and Sutter Basin, CA. The intent was to select two pilot studies on 10 February 2011 from these three studies unless more suitable studies were brought forward prior to 8 February 2011. Additional pilot studies will be selected from the nominations due by 23 February 2011.

3. No additional pilot studies were proposed by the close of business 7 February 2011 due date, so the selection panel proceeded with the three potential pilot studies outlined in the 3 February 2011 memorandum. The selected pilot studies are Jordan Creek (Springfield), MO and Sutter Basin, CA. Central Everglades, FL will remain under consideration for future selection as a pilot study.

- Jordan Creek (Springfield), MO has available Federal and non-Federal funds necessary to complete the study. The Feasibility Scoping Meeting (FSM) is currently scheduled for March 2011, and strong engagement and support of the sponsor, as well as existing vertical team engagement makes this project ideal for initial selection. Southwestern Division supports the study for inclusion as a pilot.

- Sutter Basin, CA is in the FY 2011 and 2012 President's Budget at an adequate level to complete the study. While the FSM for the study has been held, information discovered during planning has resulted in integration and consideration of new data and an expanded study area. The study has the strong support of South Pacific Division and the study sponsor for inclusion in the National Pilot Program.

4. Congratulations to these project delivery teams on their selection as the first representatives of the National Pilot Program. The National Pilot Program studies will proceed with vertical team coordination, a kick-off webinar, and pilot project activity scoping, including refinement and

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communication of expectations, development of the path forward, and further definition of outcomes and indicators of success. The webinar will provide additional information and direction on the pilot program and will be held prior to 28 February 2011. Pilot Program project delivery teams will be contacted no later than 18 February 2011 to coordinate dates for the scoping meetings. The scoping meeting will be the official start of the National Pilot Program and will be held in early to mid-March.

5. We look forward to receipt of your additional nominations and appreciate your responsiveness and commitment to this important Civil Works initiative.

FOR THE COMMANDER:

Encls Thanks for Your Support!

WILLIAM T. GRISOLI
Major General, USA
Deputy Commanding General
for Civil and Emergency Operations

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CHIEF, CEMP-CR
DIRECTOR, IWR

Sutter Basin, California

Pilot Feasibility Study

Decision Point #2

Report Summary

US Army Corps
of Engineers

Sacramento District
Version: 26 October 2012
Revised: 10 March 2013

This Report Summary is in support of Decision Point #2 and Presentation. Additional background information on the Sutter Basin pilot process, plan formulation, evaluation metrics, etc. can be found in the supporting Read Aheads for Decision Point #2.

As a Read Ahead, a Draft Report Table of Contents with referenced supporting and IPR directed documents (MFRs, papers, reports, etc) generated by the PDT during the pilot and plan formulation process is provided to show how the work efforts and documents will flow into an integrated Draft Report.

The Report Summary has been modified to be consistent with the actual Decision Point # 2 presentation, reflecting modifications in the identification and analysis of alternatives after the original document was prepared; and to provide additional information as requested by the Vertical Team after the Decision Point Conference to support the District's recommendations to identify the Locally Preferred Plan as the Tentatively Selected Plan with full Federal cost participation as prescribed by Section 103 of WRDA 1986.

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1. INTRODUCTION

Purpose. The purpose of the Report Summary is to document the planning process leading up to the recommendation of the tentatively selected plan (TSP) and in doing so reaffirm Federal interest, identify the national economic development (NED) plan, identify the locally preferred plan (LPP), and evaluate residual risk. Plans were evaluated at a suitable level of detail for the identification of the NED and LPP plans. Refined analysis, including total project costs, will be presented in the Draft Feasibility Report. Section 8 recommends the Tentatively Selected Plan (TSP).

Study Authority. The authority for the USACE to study Flood Risk Management (FRM) and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962, Pub. L. No. 87-874, § 209, 76 Stat. 1180, 1196 (1962).

Local Sponsors. The non-Federal project sponsors include the State of California Central Valley Flood Protection Board (CVFPB) and the Sutter and Butte County Flood Control Agency (SBFCA).

Study Background. The Sutter Basin Feasibility Study was initiated in 2000 and a Feasibility Scoping Meeting was held in January 2005. However the study remained essentially inactive until the formation of the Sutter Butte Flood Control Agency (SBFCA), which agreed to serve as the local partner along with the Central Valley Flood Protection Board (CVFPB) in 2007. In 2010, the Sutter Basin population passed a $6.65 million per year assessment to study and implement a project to reduce flood risks to the basin. This action was a strong public endorsement of the need for immediate action to address the flood threat, particularly since the area is an economically disadvantaged community under California State guidelines with widespread unemployment, and the approved assessment rates are among the highest in California.

Pilot Program. The Sutter Basin Feasibility Study is one of the first two studies selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that were developed by a workgroup of planning and policy experts from USACE and the Office of the Assistant Secretary of the Army for Civil Works (ASA (CW)), referred to as the 17+1 Team, for the purpose of modernizing the Civil Works Planning Program to better address the many water resource challenges facing the nation.

The revised study paradigm envisions a more predictable, and efficient process which significantly lessens the time required to complete a feasibility study. This new process requires heavy involvement as well as input and timely decisions from the Vertical Team at multiple points throughout the study. Further, the process emphasizes the early identification of the federal interest in resolving a water resource problem.

The study process continues to use sound professional engineering, economics, and environmental judgment and analyses, but appropriately focuses the amount and type of data collected and analysis on the risk and consequences of the decisions being made. Costs and benefit estimates presented herein are based on an appropriate level of detail for screening of draft alternatives to a final array. The appropriate level of detail was selected considering that comparative cost estimates are more accurate than absolute cost estimates. This is because similar errors are made for all alternatives. The range of confidence in cost and benefit estimates is presented in a table comparing the alternatives. To avoid confusion, only mean estimates are described in the text.

After approval by the ASA-CW a more detailed total project cost estimate will be completed and certified for the Recommended Tentative Selected Plan (TSP). It is anticipated that the certified total project cost estimate and the benefits of the TSP will deviate from the values presented in this report. However the estimates are expected to fall within the range of estimates provided.

The new study paradigm recognizes that qualitative optimization of any factor, including net national economic development benefit, should not be the primary factor in the Corps decision for a recommendation for federal investment. Alternative Comparison and Selection recognizes that there is no single "best" plan, and there are a variety of approaches (quantitative and qualitative) to multi-criteria decision making.

The pilot study is divided into four phases, each with a key decision point and associated In-Progress Reviews (IPRs). Table 1 summarizes the four pilot study phases and associated decision points. Based on the pilot program principles, the Sutter Basin Pilot Feasibility Study strategy focuses on utilizing an appropriate level of detail based on the decisions being made at each stage of the study. This strategy includes qualitative analysis that will be increasingly detailed at each Decision Point or IPR and early elimination of alternatives with little probability of implementation.

Table 1. Pilot Study Phases and Associated Decision Points

Pilot Study Phase	Decision Point	Date
Scoping	1 – Federal Interest Determination	Aug 2011
Analysis	2 – Tentatively Selected Plan	Nov 2012
Review	3 – Civil Works Review Board	Summer 2013*
Confirmation	4 – Chief's Report	Fall 2013*

*Dates are pending confirmation from vertical team.

Central Valley Flood Protection Plan. The Central Valley Flood Protection Act of 2008 (CVFPA), passed by the California legislature as Senate Bill (SB) 5, directs local flood risk management efforts. The CVFPA, along with other companion legislation, required the Central Valley Flood Protection Board to adopt the Central Valley Flood Protection Plan (CVFPP) by July 2012. The purpose of the CVFPP was to guide California's participation in managing flood risk along the Sacramento and San Joaquin River systems. The CVFPA requires a 200-year (with 95% assurance (or "freeboard")) level of flood protection for urban and urbanizing areas by the year 2025.

The CVFPP proposes an initial system wide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the State Plan of Flood Control (SPFC). This investment approach includes system and regional elements, some of which are located in the Sutter Pilot study area. The CVFPP was adopted by the State in July 2012. The Sutter Basin Pilot Study is continuing close coordination with these CVFPP efforts and is a key means of implementing a portion of the CVFPP.

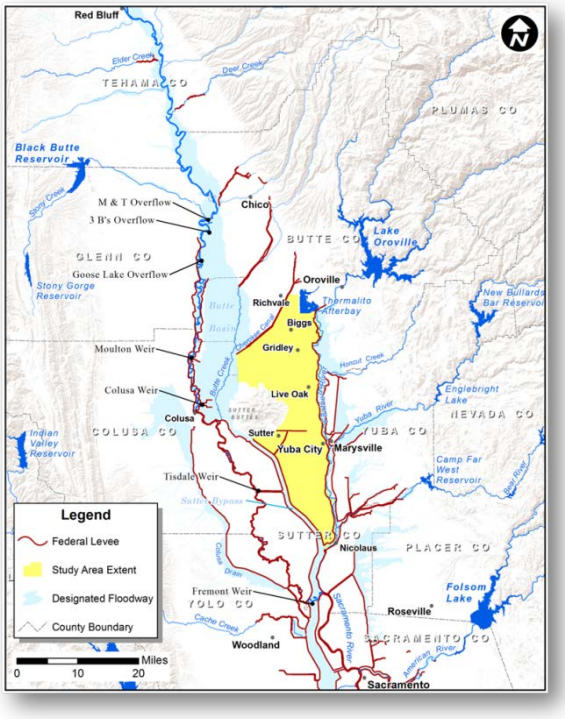
The CVFPA, recognizing the urgent need to improve the existing flood protection system, allows urban flood improvement projects (Early Implementation Projects) to be funded with State bond funds in advance of full implementation of the CVFPP. Proposed improvements must be for flood management construction projects that: rehabilitate, reconstruct, replace, improve, or add to the facilities of the State Plan of Flood Control; reduce or avoid risk to human life in urban areas; and not impair or impede future changes to regional flood protection. Construction of 3,400 feet of setback levee to replace a portion of the existing west bank Feather River levee south of Yuba City was recently completed within the Sutter Basin study area under the Early Implementation Program to address through-seepage, underseepage, and flow constriction issues. A request for approval under 33 USC § 408 was granted and an application for consideration of Section 104 credit was approved in 2009.

SBFCA is proposing another levee improvement project along the Feather River west levee under the Early Implementation Program. This project proposes to construct levee improvements between the Thermalito Afterbay and an area north of the Feather River/Sutter Bypass confluence. The project will address through-seepage, underseepage, and embankment instability of the levees, by meeting current design standards. A Pre-Design Formulation Report was completed in August of 2011 and the 60% design was completed in March 2012. An EIS/EIR is being prepared for the project as part of a Section 408 application to obtain permission from USACE to alter project levees. The non-federal project sponsors will seek in-kind credit for this local project under the provisions of Section 221 of the Flood Control Act of 1970, as amended.

2. STUDY BRIEFING

Study Area. The 300 square mile Sutter Basin study area is located in Northern California in Sutter and Butte Counties within the 14,000 sq. mile Sacramento River Watershed as shown in Figure 1. The study area, which is approximately 50 miles north of Sacramento, is bounded by the Feather River on the east, the high ground of the Sutter Buttes on the west, the Sutter Bypass on the southwest, and Cherokee Canal and the Butte River on the northwest. Existing levees along the Feather River, Sutter bypass, Cherokee canal, and Wadsworth Canal as well as the Butte Basin are features of the Sacramento River Flood Control Project (SRFCP), authorized by Congress in 1917. The SRFCP incorporated features such as levees, weirs, and pumping facilities into a system of leveed river channels and flood bypass channels to provide Flood Risk Management benefits to the Sacramento Valley. The existing levees provide FRM benefits to the Sutter River Basin study area; however, the current condition of the levees are assessed to have relatively high risk of failure as a result of through and under seepage concerns.

Figure 1: Sutter Basin Study Area

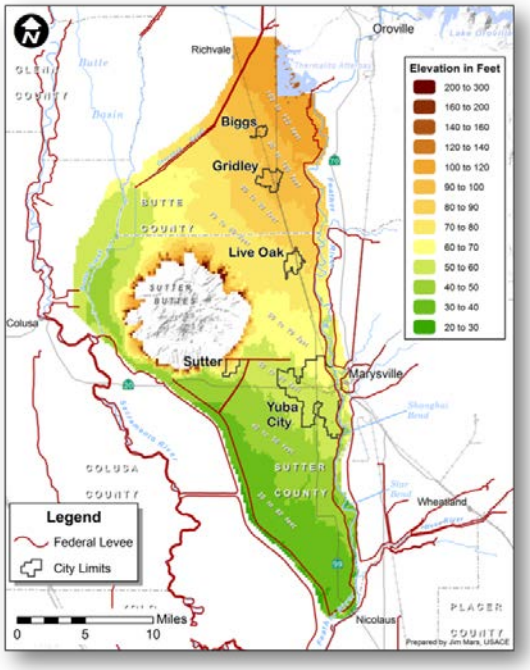


The study area is primarily rural, with extensive agricultural areas and low population density. Yuba City is the largest community in the study area, located midway in the basin adjacent to the Feather River. The northern basin 'gold rush era' cities of Biggs, Gridley, and Live Oaks are situated roughly along the north-south railroad and State Highway 99 corridors.

Existing Conditions. Existing conditions are those at the time the study is conducted and form the basis for extrapolation to other conditions. Existing conditions within the study area are discussed below.

Topography. As shown in Figure 2, the floodplain elevations (excluding the high ground of Sutter Buttes) range from 110 feet-NAVD88 in the northeast to 30 feet-NAVD88 in the southwest.

Figure 2. Sutter Basin Topography



Geotechnical Levee Performance. From initial information and modeling during plan formulation, the primary risk of flooding in the Sutter Basin is the result of geotechnical failure of the existing levees not hydrologic or hydraulic factors which result in levee overtopping. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees within the study area do not meet USACE levee design standards and are at risk of breach failure at stages considerably less than levee crest elevations. This was evidenced by historical boils and heavy seepage at stages less than authorized design flows[1]. Underseepage failures are sudden and unpredictable, resulting in minimal warning time, and ineffectiveness of evacuation plans. The risk of unexpected levee failure coupled with the consequence of flooding presents a continued threat to public safety, property, and critical infrastructure. Initial WSEL's where a seepage related levee failure becomes possible are as low as the 20% (1/5) event in most cases along the Feather River. At the 10% (1/10) WSEL, the probability of failure can range from 10-20%, while at the 1% (1/100) WSEL these probabilities of failure range from 30-45% depending upon the location along the river.

Hydraulics. Multiple levee breach scenarios were modeled along the Feather River and Sutter Bypass to assist in the analysis of the study alternatives. Floodplains resulting from levee breaches differ significantly in nature depending on the location of the breach as illustrated in Figure 3. Simulated breaches along the northern portion of the Feather River flood the northern basin in a shallow (up to 6 feet) northeast to southwest flooding flow. Breaches from the Sutter Bypass and southern most portion of

[1] Design flows obtained from USACE file drawing 50-10-334, Levee Channel Profiles, 15 March 1957. For a discussion and comparison of design flows vs. regulated and peak unregulated flows see Progress Document #2; Technical Support Documentation of the Sutter Basin Pilot Feasibility Study.

the Feather River only flood the deeper (up to 25 feet) southern basin area and do not impact the northern portion of the basin. The velocity of floodwaters varies depending on the proximity to the breach location. For those structures/people within 1,000 feet of a breach the velocity could be high enough to knock structures off of their foundations. This high risk velocity area would consist mainly of the small population of Yuba City within 1,000 feet of the river and would see velocities well above 6 feet per second (fps). But, the majority of Yuba City and all of Biggs, Gridley and Live Oak are outside this area and could expect to see flood velocities between 2-3 fps.

Figure 4 shows the composite 1% ACE floodplain for the Sutter Basin.

Figure 3. Simulated Levee Breach Scenarios

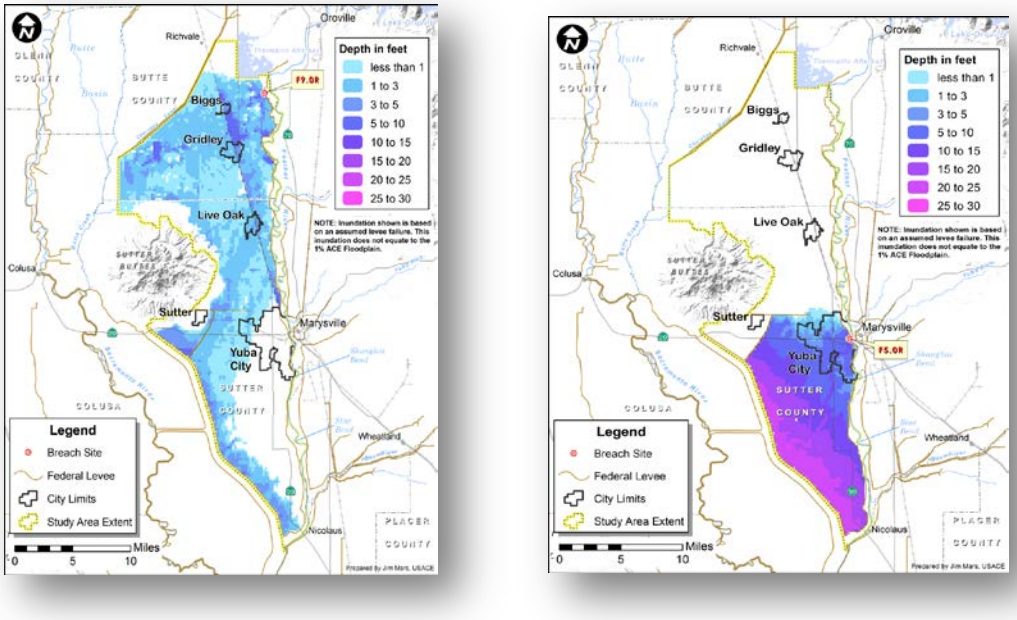
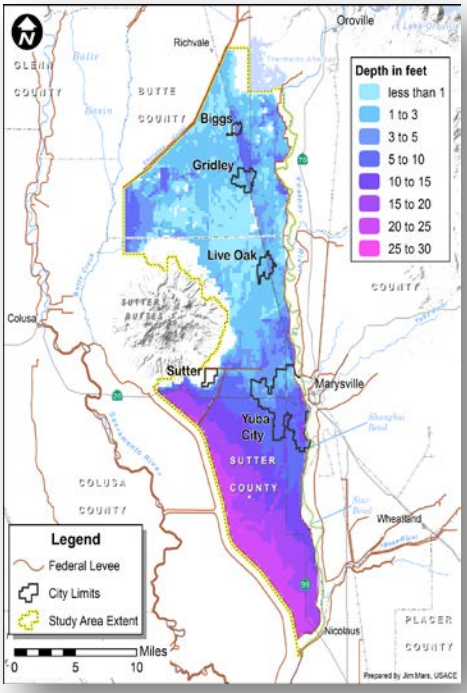


Figure 4. 1% ACE Without Project Floodplain



Economics. Based upon the 2010 Census, the population of the Sutter Basin is estimated to be 95,360 and distributed as shown in Table 2.

Table 2. Population Within Study Area

Economic Impact Area	Population
Town of Sutter	250
Yuba City Urban	67,370
Biggs Urban	1,760
Gridley Urban	6,380
Live Oak Urban	8,360
Sutter County Rural	6,340
Butte County Rural	4,900
TOTAL	**95,360**

Demographics: Median household income for the study area ranges from $36,563 (Gridley) to $48,830 (Yuba City). Both of which are below State ($61,632) and national (52,762) averages. The persons living at or below the poverty level in the study area are 22.7%, 21.4% and 15% for Biggs, Gridley and Yuba City, respectively. All of which are above the State (14.4%) and national (14.3%) averages.[2]

The total labor force in the study area is estimated at 40,000, with an unemployment rate of 14.7%, 8.4%, and 9.3% in Biggs, Gridley and Yuba City, respectively. Total private wage or salary workers estimated to be 75% (Biggs), 65% (Gridley) and 69% (Yuba City) with 17% (Biggs), 25% (Gridley) and 20% (Yuba City) of the labor force rated as government workers. Approximately, 7% (Biggs), 11% (Gridley) and 11% (Yuba City) of the labor force was considered to be self-employed, not incorporated. The average wage per job so the study area is between $22,300 to $28,100.

Variances in race and ethnicity in communities may impose language and cultural barriers that affect ability to cope with natural hazards. The Hispanic presence is evident given they make up at least 28% of the population in each community. Live Oak's population is composed of 48.8% of individuals of Hispanic origin, which is significantly higher than the State average of 37.6% and considerably exceeds the national average of 16.3%.

Inventory: An economic inventory was assembled following standard USACE methods. For the study area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sutter and Butte counties. Field visits were conducted to collect and validate the base inventory data. Parcels with structures were categorized by land use and grouped into residential, commercial, industrial or public categories. The value of damageable structures was estimated based on depreciated replacement values. The total value of damageable property (structures and contents) within the Sutter Basin study area is estimated at $6.9 Billion (October 2011 prices). Table 3 displays the structural inventory by land use category. Total study area without project expected annual damages are approximately $108 million.

[2] Some demographic data was unavailable for the City of Live Oak.

Table 3. Structural Inventory –Existing Conditions[3]
Number of Structures within 0.2% (1/500yr) Annual Chance Floodplain

Economic Impact Area	Commercial	Industrial	Public	Residential	TOTAL
Biggs	18	1	0	586	**605**
Gridley	81	7	4	1,931	**2,023**
Live Oak	51	5	23	2,088	**2,167**
Yuba City	872	210	122	18,760	**19,964**
Town of Sutter	0	0	0	0	**0**
Rural Butte	10	16	0	1,242	**1,268**
Rural Sutter	10	29	8	1,162	**1,209**
TOTAL	**1,042**	**268**	**157**	**25,769**	**27,236**

Climate. The study area is located within the northern portion of California's Central Valley. The Sacramento Valley is a semi-arid region with an annual rainfall of approximately eighteen inches. There are two distinct annual seasons, a hot dry summer and a cool wet winter. Approximately eighty percent of the annual rainfall occurs in between October to March.

Environmental. Sutter County is primarily rural, with extensive agricultural areas and a low population density. The county is one of California's major agricultural counties and its traditional job base is agriculture. A number of Federal and State listed species are known to occur or potentially occur in the study area. Many of these species are located within the riparian areas along the Feather River.

Historic Flooding. In 1955, flood waters from a levee breach encompassed a significant portion of the study area inundating 6,000 homes, drowning 38 people, injuring 3,200 individuals, and requiring 600 people to be rescued by helicopter. From 1950 to 2011, extensive flood fighting has occurred during 19 events, and deadly levee failures adjacent to the Sutter Basin took place in 1986 and 1997 which reduced stress on the levees surrounding the Sutter Basin and may have resulted in avoiding failure of these levees. Flooding historically has occurred during the months of December through February with air temperatures of 38 to 55°F and water temperatures of 45 to 55°F; temperatures which significantly increase risk of death by exposure[4].

Future Without-Project Conditions. The future without-project condition is the most likely condition expected to exist in the future in the absence of a proposed water resources project and constitutes the benchmark against which alternatives are evaluated. These forecasts of future conditions are from the base year (year when a project is expected to be operational) to the end of the period of analysis (50 years). Future without-project conditions for this study are projected assuming a base year of 2020 and a 50-year period of analysis out to year 2070. Assumptions regarding the future without-project condition are listed below:

- For purposes of evaluating the transfer of flood risk, the future without-project condition will assume the levees do not fail due to geotechnical conditions since their original design was not based on failure assumptions.

- Ongoing levee maintenance will result in no change to geotechnical conditions and levee

[3] Based on empirical analyses conducted for past Corps projects, subject matter expertise from the agricultural economist and professional judgment, the project delivery team expects agricultural damages to total 10-15% of total project damages; amounts which are not expected to drive plan selection. A simplified approach was developed for this study.

[4] United States Coast Guard

performance curves.

- Oroville and New Bullards Bar reservoirs on the Feather and Yuba River Systems will continue to be operated using the existing rule curves.

- Vegetation and topographic conditions within the channel are expected to remain the same as existing conditions.

- Remaining natural areas are not expected to substantially decline in acreage and value over the period of analysis.

- Economic analysis assumes the future without-project condition damages are equal to existing conditions. Because any future without project development would take place outside/above the mean 1% (1/100) ACE floodplain boundary and because any future damages would be discounted back to present value, the future condition is not expected to impact the plan formulation process significantly.

- Since refinements, additions, and deletions of elements associated with the System wide Investment Approach presented in the 2012 CVFPP are anticipated, these elements will not be included in the future without-project condition.

- Flood frequency will be based upon existing conditions. However, a sensitivity analysis of climate change impacts on hydrologic frequency, flood damages, and alternative selection will be conducted. This approach was based on a review of uncertainty in recent climate model analysis.

- Assumes Three Rivers Levee Improvement Authority (TRLIA) Feather River setback levee has been constructed.

- Section 104 of WRDA 86 allows for the plan formulation analysis to exclude work conducted by the sponsor from the without project condition, thereby allowing the work to potentially be incorporated in to the recommended plan, if it is found to be in the Federal interest. Since the application for consideration of Section 104 credit for the completed Star Bend setback levee was approved in 2009 prior to the moratorium on consideration of Section 104 credit by the ASA (CW), this project will not be considered part of the future without-project condition.

- Vertical Team policy guidance provided at In-Progress Review #1 recommended that the Feather River West Levee Project proposed by the project sponsor will not be considered part of the future without-project condition (assumes no contract prior to the Chief's Report for the pilot study). If appropriate after the feasibility report is completed, the sponsor may request credit consideration for this local project under the provisions of Section 221 of the Flood Control Act of 1970, as amended. This may be accomplished in accordance with ER 1165-2-208 guidelines.

3. PLANNING OBJECTIVES AND OPPORTUNITIES

Following inclusion of the Sutter Basin Feasibility Study in the National Pilot Program, the Project Delivery Team (PDT) and non-Federal sponsors participated in a study risk workshop with several members of the Vertical Team during which the following problem, opportunity, objective, and constraint statements were developed and refined.

Problems.

- A high risk of flooding from levee failure threatens the public safety as well as property and critical infrastructure throughout the study area
- Existing levees have isolated the floodplains from waterways, which has eliminated significant floodplain habitats for native species, including Federally listed species and other special status species; also, conversion of high value habitats to other land uses has reduced the abundance, distribution and diversity of native species

Opportunities.

- Land formerly converted by mining or agriculture can be restored to more natural habitats in conjunction with FRM
- Facilities can be included at recommended FRM and Ecosystem Restoration (ER) features to provide public access and use and improved outdoor recreation experiences

Objectives.[5] The study objectives were developed through the integration and use of the four planning accounts, which include national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE).

- Reduce the risk to life, health, and public safety due to flooding
- Reduce the risk of property damage due to flooding
- Reduce the risk of damage to critical infrastructure due to flooding
- Encourage wise use of the floodplain
- In conjunction with FRM, restore floodplain connectivity and associated dynamic riverine processes
- In conjunction with FRM, restore aquatic, wetland, riparian and terrestrial habitats for special status and other native species
- In conjunction with FRM and ER, improve the public's access to and use of outdoor recreational opportunities in the study area

Constraints.

- Minimize adverse hydraulic effects where they could result in economic damages to others
- Minimize significant adverse impacts to the human environment
- Comply with applicable Federal laws, regulations, and policies such as the National Environmental Policy Act, Endangered Species Act, Fish and Wildlife Coordination Act, Clean Water Act, and the National Historic Preservation Act.

Evaluation Metrics. Evaluation metrics were developed to compare alternatives. During plan formulation, as measures and alternatives were developed, better and more cost effective ecosystem and recreational opportunities were identified that were not conjunctive to the FRM measures and alternatives being carried forward to the array of alternatives. These objectives, ecosystem and recreation, were therefore not integrated into the final evaluation metrics and the multi-criteria analysis which directed focus on the life safety metrics.

[5] Additional non-Federal objective entailed reducing the probability of flooding to urban and urbanizing areas to less than 0.5% (1/200) annual chance exceedance due to CA State Law requiring a 200-year level of flood risk management by the year 2025.

The *Sutter Basin Pilot Study Re-scoping Plan* stated that it was anticipated that evaluation and comparison of the final array of alternatives would be based on monetary and non-monetary effects, qualitative and quantitative data, and economic, public safety, environmental, and regional criteria. The evaluation criteria (Table 4) identified were based on both existing Corps policy, including the Principles and Guidelines, and Planning Guidance Notebook.

Table 4. Evaluation Criteria based on P&G and PGN

Study Objectives	Evaluation Metric
(a) Reduce the risk of life, health, and public safety due to flooding	Population at Risk
	Critical Infrastructure-Life Safety
	Evacuation Routes
(b) Reduce the risk of property damage due to flooding	NED Costs
	NED Benefits
(c) Reduce the risk of damage to critical infrastructure due to flooding	Critical Infrastructure-Life Safety
(d) Encourage the wise use of the floodplain	Potentially Developable Floodplain (Acres)

Definitions of the evaluation metrics used in the Sutter Basin Feasibility study are shown in Table 5. These evaluation metrics were presented and discussed during the In-progress Review Meeting #4 on 26 June 2012 and were approved by the Vertical Team.

Table 5. Description of Metrics

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE Floodplain based on the 2010 census blocks.
Critical Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, and jails that are of life safety significance.
Evacuation Routes (# of Routes)	Assesses the vulnerability of populations with regards to the number of escape routes available during flood events.
Potentially Developable Floodplain (Acres)	Potentially developable land within the 0.2% ACE floodplain. Acres of land with 1% ACE flood depths less than 3 feet.

4. PLAN FORMULATION

The plan formulation process develops and evaluates alternative plans to address the needs and desires of society as expressed in specific planning objectives. Accordingly, the tentatively selected plan best satisfies the objectives as well as the Federal interest, which are consistent with the Federal Water Resources Council's Principles and Guidelines (P&G) and the Planning Guidance Notebook (ER-1105-2-100).

Management Measures. A broad array of management measures was developed based on information from existing reports and studies, as well as public input and professional judgment. These measures were presented at the Sutter Basin Pilot Study Critical Thinking Charette held at the Sacramento District on July 18-19, 2011. The charette was attended by the PDT and non-Federal sponsors, along with several members of the Vertical Team and the National Pilot Program 17+1 Team. The team reviewed each measure, identified additional measures, and then evaluated the measures based on study objectives, study constraints, and Water Resources Council Principles and Guidelines (P&G) criteria. A group decision was made as to whether each measure should be retained or dropped from further consideration. Progress Document #1 provides a description of the measures evaluated at the charette and indicates whether each one was retained or dropped and the reason(s) for dropping.

Preliminary Alternative Formulation and Evaluation. Following the initial screening of measures, the team identified four themes (strategies) for plan formulation. The themes included the following: 1) Consequence Management Focused on Public Safety, 2) Urban FRM Focus, 3) Maximize Existing System with FRM Focus, and 4) Ecosystem Restoration Focus. These themes were used to assist the team in establishing a preliminary array of conceptual alternatives by grouping measures according to the primary focus of each theme. Based on the measures grouped under each theme, the team identified a total of nine conceptual alternatives[6]. Most alternatives are comprised primarily of new levees or strengthening of existing levees. Following the charette, each alternative was further developed and quantities, costs and economic benefits were estimated for each alternative. The use of these results was used solely to screen out those preliminary alternatives that do not appear economically justified even in the most favorable conditions.

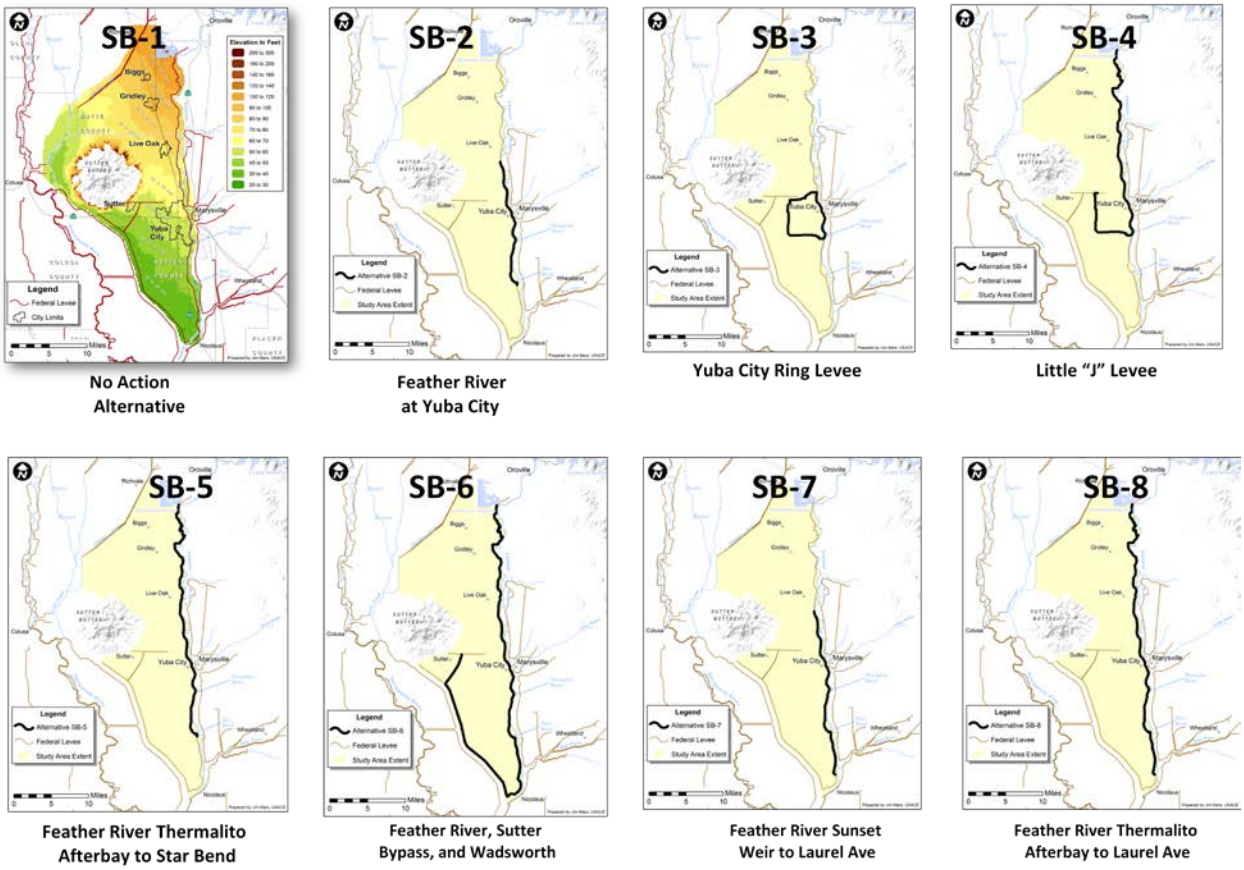
Draft Alternative Evaluation and Comparison. A combined Value Engineering (VE) Study and Planning Charette was held from October 31st to November 4th, 2011. The VE methodology was incorporated into the planning process at an early stage of the study to compare, refine, and optimize alternatives based on multiple criteria in order to ensure a robust array. This process also provided an opportunity to validate the array of preliminary alternatives and to ensure that significant alternatives had not been overlooked. The VE Study/Charette was attended by the PDT and non-Federal sponsors, the Sacramento District (SPK) VE Officer and South Pacific Division (SPD) VE Program Manager, the SPD Plan Formulation Lead, and representatives from the National Pilot Program 17+1 Team. Based on the discussions during the combined VE Study/Charette, the team identified alternatives with very similar functions in addition to those with little probability of implementation. This resulted in combining and eliminating some of the alternatives as well as refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array. The draft array of alternatives (shown in Figure 5) evaluated in further detail includes:

- Alternative SB-1: No Action Alternative.

[6] A matrix with the array of conceptual alternatives and measures associated with each of these alternatives is also included in Progress Document #1 where the nine conceptual alternatives are described by theme.

- Alternative SB-2: Fix in Place Feather River from Sunset Weir to Star Bend - This alternative involves strengthening the existing Feather River levee in the immediate vicinity of Yuba City and reduces risk to the Yuba City urban core.
- Alternative SB-3: Yuba City Ring Levee – This alternative includes the construction of a new levee surrounding Yuba City and reduces risk to the primary urban center.
- Alternative SB-4: Little "J" Levee – This alternative includes strengthening the Feather River levees north of Yuba City and construction of a new levee on the south and west of Yuba City. Reduction of risk is focused on Yuba City and the northern communities of the Basin.
- Alternative SB-5: Fix in Place Feather River, Thermalito Afterbay to Star Bend- This alternative includes SB-2 but extends levee improvements north to Thermalito.
- Alternative SB-6: Fix-in-Place Feather River, Sutter Bypass, and Wadsworth Canal- This alternative consists of the Sutter Bypass / Wadsworth Canal Levee Improvements and the Feather River Levee Improvements.
- Alternative SB-7: Fix in Place Feather River, Sunset Weir to Laurel Ave- This alternative includes SB-2 but extends Feather River fix-in-place levee improvements south of Yuba City to Laurel Ave that specifically addresses residual risk of Yuba City southeastern areas.
- Alternative SB-8: Fix-in-Place Feather River from Thermalito Afterbay to Laurel Ave – This alternative focuses on the Feather River Levee Improvements north to Thermalito and south to Laurel Ave. Reduction in risk is focused on Yuba City and the northern communities of the basin.

Figure 5: Alternatives



Identification of the NED Alternative. Table 6 summarizes the expected annual net benefits and the benefit to cost ratio ranges for each of the draft array of alternatives. The economic analysis indicates the national economic development alternative to be SB-7, as it maximizes net benefits. Alternative SB-7 comprises of fixing-in-place the existing Feather River from Sunset Weir down river to Laurel. The total first cost estimate is $423 with annual net benefits of $37 million. Figure 6 shows the Alternative SB-7, NED plan and the resulting with project residual floodplain.

Table 6: Alternative Economic Evaluation and Comparison[7]

Alternative	Total First Cost			IDC	Annualized Cost + O&M			Annual Benefits			Annual Net Benefits			Benefit to Cost Ratio		
	Low (20%)	Mid (50%)	High (80%)	Mid	Low (20%)	Mid (50%)	High (80%)	Low (75%)	Mid (50%)	High (25%)	Low	Mean	High	Low	Mean	High
SB-1: No Action	0	**0**	0	0	0	**0**	0	0	**0**	0	0	**0**	0	0.0	**0.0**	0.0
SB-2: Minimal Fix in Place, Sunset Weir to Star Bend	290	**319**	361	24	14	**16**	18	24	**38**	73	14	**29**	48	1.9	**2.9**	4.1
SB-3: Yuba City Ring Levee	411	**451**	507	53	21	**23**	26	25	**41**	71	8	**23**	40	1.3	**2.0**	2.7
SB-4: Little J Levee	729	**798**	899	94	37	**40**	45	31	**46**	87	-3	**14**	36	0.9	**1.4**	1.9
SB-5: Fix-in-Place, Thermalito to Star Bend	549	**608**	694	72	28	**31**	35	29	**45**	81	4	**21**	41	1.1	**1.7**	2.3
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal	1,018	**1,131**	1,297	183	53	**59**	67	46	**73**	134	-3	**24**	58	0.9	**1.4**	2.0
SB-7: Fix-in-Place, Sunset Weir to Laurel Ave	386	**423**	479	41	19	**21**	24	32	**51**	92	18	**37**	60	1.8	**2.7**	3.8
SB-8: Fix-in-Place, Thermalito to Laurel Ave	645	**713**	812	100	33	**37**	42	36	**58**	101	7	**28**	52	1.2	**1.8**	2.4

Alternatives SB-2 and SB-7 result in the highest net benefits. Further evaluation of the NED Alternative (SB-7) when compared to (SB-2) indicates that the NED plan reasonably maximizes economic benefits and provides additional outputs in terms of the other accounts (Table 7). Alternative SB-2 consists of fixing-in-place the Feather River levees from Sunset Weir to the downstream end of Star Bend. The total first cost estimate is $319 million with annual net benefits of $29 million. Benefits are concentrated in the primary urban center of the study area, Yuba City. The next added fix, Alternative SB-7, comprises of fixing-in-place the existing Feather River levees from Sunset Weir down river to Laurel Avenue. This alternative consists of SB-2 fixes plus an additional 13.4 mile of levee fixes. The total first cost estimate is $423 million with annual net benefits of $38 million. The additional investment of $104 million results in an increase in net benefits of $8 million. The incremental benefit-to-cost ratio is 2.6. Benefits for this additional reach are also centered in Yuba City, but address significant flood risk to the southern urban portion of the city. Fixing this reach provides flood risk reduction to approximately an additional 18,500 people.

[7] The net benefits were computed using screening level cost estimates, which incorporated results from a cost risk analysis. As such, a range of confidence was derived for each cost estimate and computed benefits. This range indicates the reliability of the estimate and benefits.

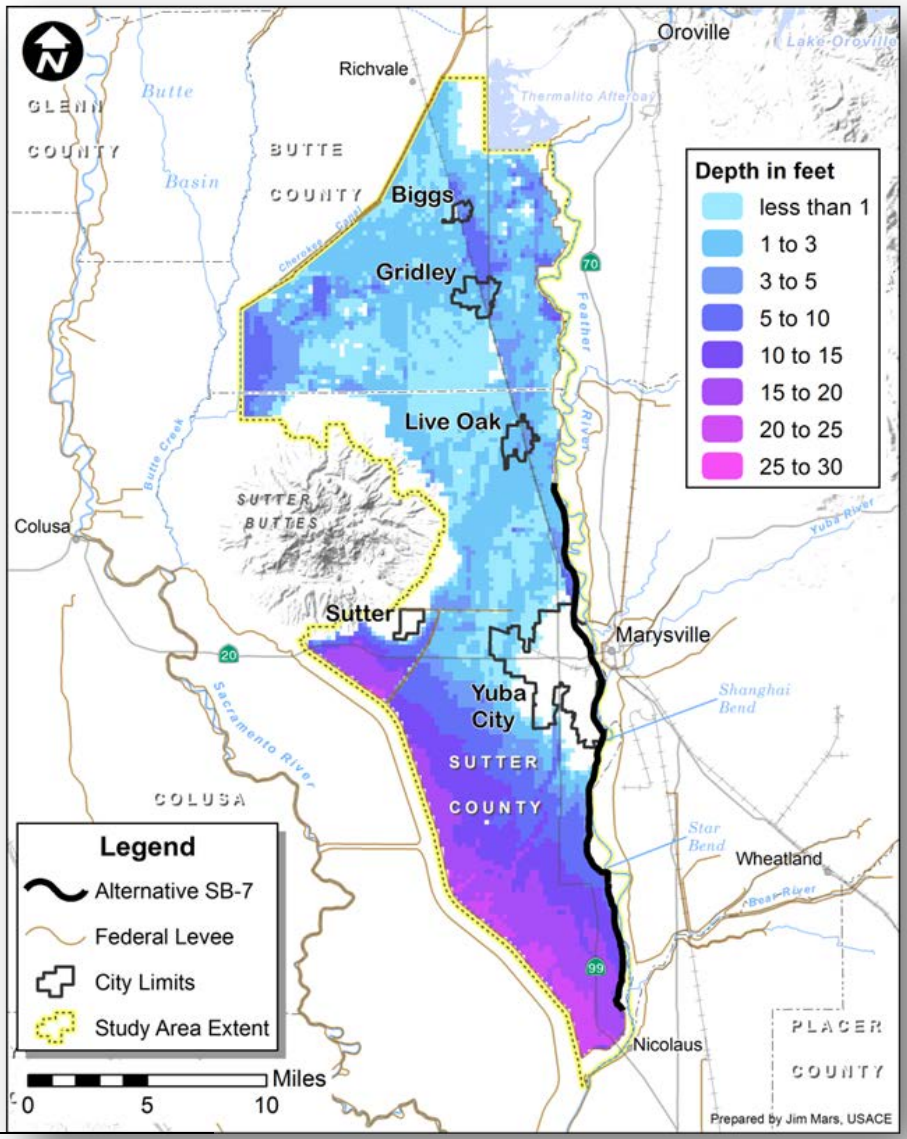
Table 7: SB-2 and SB-7

Item (from mean economic range number)	**Alternative SB-1 No Action**	**Alternative SB-2 1st Increment**	**Alternative SB-7 NED**
Investment Cost (millions)			
First Cost	-	319	423
Interest During Construction	-	24	41
Total	-	343	464
Annual Cost (millions)	-		
Interest and Amortization	-	15.8	20.7
OMRR&R	-	0.2	0.4
Subtotal	-	16	21
Annual Benefits FRM (millions)	-	38	51
Multi Objective Accounts (non-monetary)			
Population Remaining at Risk (people)	94,600	**56,700**	**38,200**
Critical Infrastructure (facilities)	28	11	11
Evacuation Routes (number of routes)	0	1	1
Wise Used of Floodplains (acres)	71,800	83,800	88,200
Net Annual FRM Benefits (millions)	-	**29**	**37**
FDR Benefit to Cost Ratio	-	**2.9**	**2.7**
FDR Benefit to Cost Ratio (at 7%)	-	1.7	1.6

5. RESIDUAL RISK OF THE NED ALTERNATIVE

Description of Residual Risk. The NED Alternative (SB-7) reduces adverse flooding effects but benefits are primarily centered on Yuba City. The alternative features do not address the significant flooding risk in the communities of Biggs, Gridley, and Live Oak. Residual risk of the NED alternative was assessed by the life safety metrics, described in Table 5. Given the NED residual 1% ACE floodplain[8] (Figure 6), substantial residual risk to Biggs, Gridley, Live Oak, and Yuba City remain (Table 8).

Figure 6. Alternative SB-7 NED Plan (1% ACE Residual Floodplain)



[8] 1% floodplains are based on the inundation from any levee having less than 95% assurance. The assurance estimate was based on geotechnical, hydraulic, and hydrologic uncertainty.

Table 8. Residual Risk of the NED Alternative, 1% ACE Floodplain

Evaluation Metric	Alternative	
	SB-1: No Action	NED Plan
Population at Risk (People)	94,600	38,200
Critical Infrastructure (Facilities)	28	11
Evacuation Routes (Number of Routes)	0	1
Wise Use of Floodplains (Acres)	71,800	88,200

Population at Risk. A remaining population of 38,200 is at risk of flooding. Of special concern is the population over the age of 65 living within the study area since those individuals have been shown to be at higher risk of life loss in flood events. Both Butte (15.6%) and Sutter (13.0%) counties are above the state average (11.7%) for percentage of persons 65 years of age and over[9].

Critical Infrastructure. A significant amount of critical infrastructure is located within the Sutter study area. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are facilities for fire stations, police stations, hospitals, senior living facilities, and prisons. The benefits of the NED Alternative (SB-7) are primarily centered around Yuba City and still at risk are 11 elements of the critical infrastructure in the communities of Biggs, Gridley and Live Oak.

Evacuation Routes. The primary urban centers in the region are Yuba City, Biggs, Gridley, and Live Oak. These communities are all located on or near California State Route 99, which runs north-south through the region. The Sutter County Evacuation and Mass Shelter/Care Plan identifies Highways 20, 99 and 113 as the primary evacuation routes in the region. These routes are subject to change since these routes are event-specific and official routes are established by the County Sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time, but anticipates Highways 99, 162 and the Colusa Highway could be used as conditions allow. During the 1997 event, seven different evacuation zones were established over seven days due to constantly changing conditions and levee breaks[10]. The main evacuation routes used for this flood event were Highway-99 north and Highway-113 south. Highway-20 west and Highway-99 south were used intermittently since all portions of these roads were not accessible at all times during the flood.

Evacuation preparation can be made days in advance for predictable flood events within the major river system surrounding the study area. As river water levels raise and are predicted to reach flood stages, warnings and evacuation efforts would be increased and reiterated. This would allow time for evacuation of immobile residents and other people with special evacuation needs (hospitals, rest homes, jails, elderly individuals, schools) via the established routes. However, none of the historical flooding evacuations in the region have been due to foreseen events. Historical flood evacuations in the region have been from levee failures due to underseepage, which is characterized by its unpredictability and sudden occurrence.

[9] Source: U.S. Census Bureau (2012).

[10] Source: Sutter County Office of Emergency Management.

The result is evacuations after levees have failed and widespread flooding is in progress. The 1955 flood occurred due to a levee break in late December where no prior evacuation notice was given. In the 1997 flood, Yuba City was evacuated and during the evacuation a levee on the east side of the Feather River near Olivehurst (which was not evacuated) broke.

The residual 1% ACE (1/100 year event) resulting from the NED Alternative affects every major urban center and nearly every primary evacuation route in the region. The floodplain is due to potential levee failure upstream of Sunset Weir. All routes out of Biggs, Gridley and Live Oak are affected by the residual floodplain. The only egress from Yuba City would be Highway 20 and 5th Street bridges east into Marysville, which is a community surrounded by a ring levee. Additionally, heading eastbound entails driving over a four lane bridge that is not expected to adequately handle the additional traffic flow, and may create a bottle neck limiting evacuation.

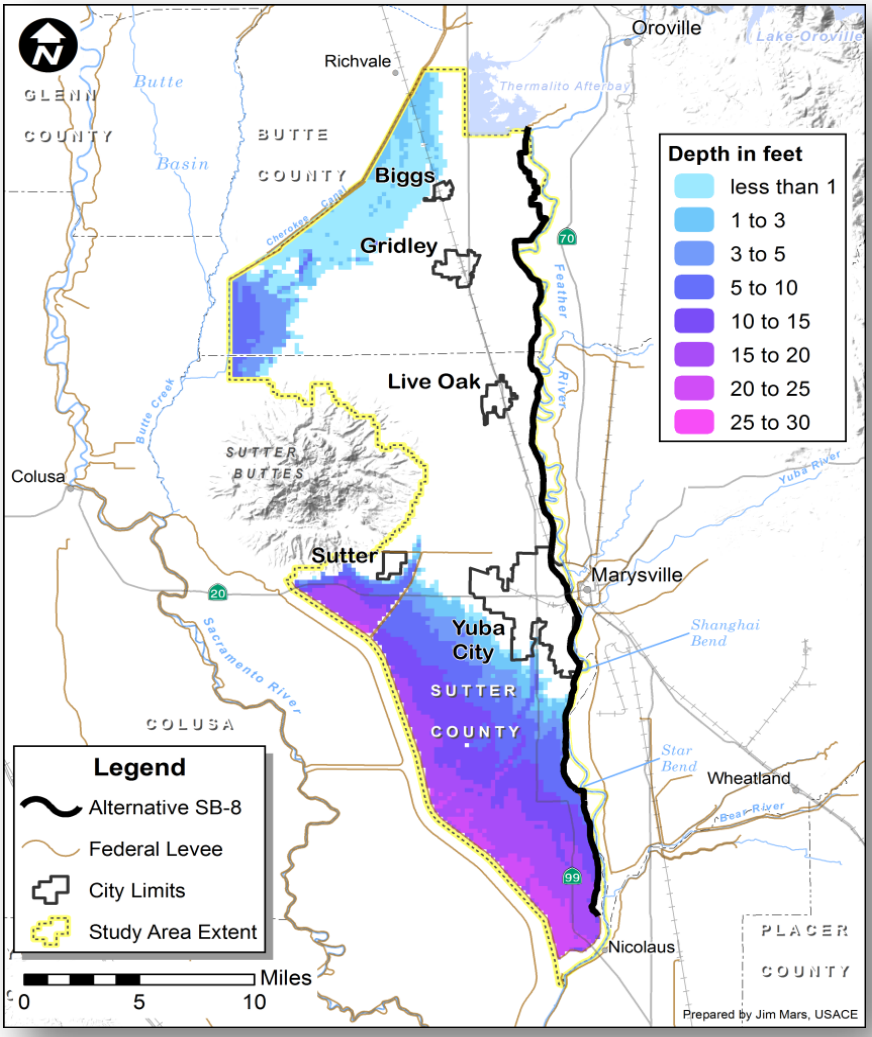
The District has initiated coordination with California Department of Transportations (CalTrans) to understand their criteria for road closures and evacuation during flood events. Standards for road closures are based less on depth and more on length of roadway affected by flooding. Road closures are determined based upon safety concerns and are authorized by the California Highway Patrol. Residual flooding in the northern area Sutter Basin associated with the NED Plan would encompass a majority or all primary roadways and would have a high likelihood of being considered impassable and/or closed using the above criteria. The sponsor has finalized its Flood Plain Management Plan, which includes coordination with State transportation authorities. The District will verify that the Future Without-Project Condition and No-Action Plan accurately represent the State and local response criteria for flood events.

Wise Use of Floodplains. A determination must be made as to whether the increase in potentially developable floodplain area is acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. It is important to remember that the floodplain metric used in this analysis is a simple index based on physical parameters. The metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. For example, current zoning ordinances in Sutter and Butte County's General Plan indicate restrictive policies, which govern future development. Local policies, combined with recent state legislation and federal regulations are expected to limit developable land. These factors should be considered in conjunction with the metric.

6. ADDRESSING RESIDUAL RISK

The NED Alternative (SB-7) reduces adverse flooding effects but significant residual risks remain. With the aim of buying down the residual risk, the PDT found the most cost-effective incremental alternative to the NED to be Alternative SB-8. Figure 7 displays the residual 1% ACE floodplain associated with Alternative SB-8. In order to better understand the nature of residual flooding and flood risk associated with the NED Plan and LPP, the District has refined flood plain mapping to 1 foot intervals for the 2%, 1%, 0.5%, and 0.2% ACE. Please see Attachment 2, MFF urban floodplains.

Figure 7. Alternative SB-8 (1% ACE Residual Floodplain)



Using life safety metrics and accounts to address the significant residual risk of the NED Plan other measures and alternatives were investigated and evaluated with Alternative SB-8 identified as a next increment plan to the NED plan that effectively and efficiently reduces the residual risk and consequences to life safety in the northern urban areas and other parts of Sutter Basin. To further ensure that Alternative SB-8 structural and formulation strategy were valid, a cost comparison of Alternative SB-8 was performed, at a conceptual level of detail, to verify the structural measures of Alternative SB-8 were the most cost effective in addressing the residual risk and consequences left by the NED Plan.

The District identified risk reduction measures to reduce loss of life and improve the function of critical infrastructure facilities. Ring levees were considered to be ineffective for facilities like hospitals, the correctional institution, and the assisted living center because the functionality of the facilities would be compromised for an average flood event, which is estimated to be 2-3 weeks (using actual historical flood events in this study area as reference). Raising smaller facilities such as the police stations and the fire stations might be economically justified, but they would not maintain their functionality during the duration of a flood event.

Specific measures to improve evacuation during a flood event were also evaluated. Measures considered included modification to the roads used for evacuation. Because flooding in the northern portion of the study area is extensive sheet flow, embankment modifications to road and the railroad would need to be raises; culverts would not convey the wide area extent of the sheet flows. Raising roads was considered to be cost prohibitive relative to other measures. Raising the railroad is considered to be more costly than raising a road so that measure was similarly screened out. Additional investigation of potential evacuation routes and destinations, such as the Sutter Buttes, will be done as part of the life safety incremental assessment of SB-7 and SB-8, to be included in the Draft Feasibility Report. Please see Attachment 1, Decision Point #2 Slides, slides 50-56).

Evaluation of critical infrastructure and evacuation life safety measures will continue to be refined for the Draft Feasibility Report.

Fixing in place levees structural measures of Alternative SB-8 are estimated at an additional cost (compared to the NED plan) of: $260 to $330 Million. The costs for various comparable nonstructural measures addressing similar residual risk areas are listed below:

- Elevate Houses: ~$650 million
- Evacuation Route – Elevated Causeway: ~$600 Million
- Ring Levees around Live Oak, Gridley, and Biggs: ~$375 Million
- Buyouts: ~$1Billion

Alternative SB-8 is the multi-objective/account alternative that is cost effective and best reduces flooding and reduces residual risk of life safety in the Sutter Basin. Alternative SB-8 is comprised of Alternative SB-7 fixes plus fixing-in-place the existing northern Feather River levees from Sunset Weir up to Thermalito. The total first cost estimate is $713 million with annual net benefits of $26 million.
The additional investment of $290 million in project cost (Alternative SB-8 first cost minus the NED Alternative cost) buys down the residual risk of the NED Alternative and provides significant non-monetized benefits (displayed in Table 9). The population at risk of flooding from a 1% ACE flood event (Plate #8) decreases from 38,200 to 6,600, life safety related critical infrastructure at risk is reduced from 11 to 1, and the number of evacuation routes increases from 1 to 5. It should be noted that the additional investment of $290 million for the LPP increment produces an incremental annual benefit of $7 million. While this is not enough to justify the full cost of the increment, it justifies more than half of it. The LPP would reduce risk to an additional 32,000 people in an area that has historically had loss of life in a flood event. The RMC is conducting a Levee Safety Alternatives Evaluation of the NED and LPP the week of 25 February 2013.

Table 9. Summary of Life Safety Metrics, 1% ACE Floodplain

Evaluation Metric	Alternative		
	SB-1: No Action	NED	SB-8
Population at Risk (People)	94,600	38,200	6,600
Critical Infrastructure (Facilities)	28	11	1
Evacuation Routes (Number of Routes)	0	1	5
Wise Use of Floodplains (Acres)	71,800	88,200	100,200

In significantly reducing the residual risk of the NED Alternative, the next incremental alternative (SB-8) is supported by the local sponsors and can be considered the federal plan in terms of comprehensiveness and completeness. Alternative SB-8 is proposed as the Locally Preferred Plan (LPP) with strong federal interest. Furthermore, considering an objective of the study is to reduce risk to lives, perhaps the LPP increment of levee (17.7 miles) is in fact non-separable from the levee improvements included in the NED Plan from a life safety perspective.

Please also refer to Attachment 1, Decision Point #2 presentation slides 47-70, for initial comparison of NED and LPP, which is also being refined for the Draft Feasibility Report.

7. FINAL ARRAY OF ALTERNATIVES & COMPARISON

With the identification of the NED Plan and the LPP, a final array of alternatives was established for the study:

- **No Action: Alternative SB-1**
- **NED: Alternative SB-7** reconfirms federal interest, reduces flood risk to most of Yuba City area, but leaves considerable residual risk to the northern communities of the basin and parts of Yuba City.
- **LPP: Alternative SB-8** reconfirms federal interest the same as the NED plan, but significantly reduces residual risk of the NED in the northern communities of the basin and parts of Yuba City. It has also been identified in terms of multi-objective planning the comprehensive federal plan.

As a final step in the multi-objective planning process, a pair-wise comparison and evaluation was completed between the NED plan and the LPP to determine the recommended Tentatively Selected Plan (TSP**)** as shown in Table 10.

Table 10: Final Array of Alternative Plans- Comparison Summary of Accounts and Criteria

	NO ACTION	NED PLAN	LPP PLAN
1. PLAN DESCRIPTION			
	Alternative SB-1: The No Action provides no physical project constructed by the Federal Government.	Alternative SB-7: The NED plan is a Feather River fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The LPP plan is a Feather River fix-in-place levee alternative from Thermalito to Laurel Avenue.
2. MULTI-OBJECTIVE PLANNING ASSESSEMENT			
A. National Economic Development (NED) – mean or mid-range numbers			
1. Project Cost	$0	$423,000,000	$713,000,000
2. Annual Cost	$0	$21,000,000	$37,000,000
3. Total Annual Benefit	$0	$51,000,000	$58,000,000
4. Annual Net Benefits	**$0**	**$37,000,000**	**$28,000,000**
5. Benefit – Cost Ratio	**N/A**	**2.7**	**1.8**
B. Environmental Quality (EQ)			
1. Environmental Safety	High potential for contaminated flood waters from the northern community urban facilities (water treatment plants; gas stations; etc)	High potential contaminated flood waters from the northern community urban facilities (water treatment plants; gas stations; etc)	Lower flood risk and lower risk of potentially contaminated flood waters from the northern urban community facilities (water treatment plants; gas stations; etc)
2. Ecosystem	The Sutter Basin is located along the Pacific Flyway that serves millions of migrating waterfowl during the winter migration (flooding) season for	Under residual flooding, thousands of acres remain impacted, negatively affecting "stop-over" feeding and resting areas with potential wildlife	Residual flooding is primarily concentrated in the south most part of the basin allowing for significant availability of acres for "stop-over" feeding and

	NO ACTION	NED PLAN	LPP PLAN
	foraging and rest. Flooding would negatively affect "stop-over" feeding and resting areas with potential wildlife health issues with contaminated waters.	health issues with contaminated waters.	resting. There is a lesser risk from urban area contamination
C. Regional Economic Development (RED)			
1. RED Effects to Flood Risk Management and Region	Future flooding would destroy part of the infrastructure resulting in a loss in the region's ability to produce goods and services. Little to no RED benefits.	A 4-year period of construction can result in positive spillovers to suppliers, short-term increases in construction related employment, increase revenues for local businesses and a potential increase in wealth for floodplain residents, as less is spent on damaged property repairs. Population and economic centers of the basin would be flooded resulting in slow regional recovery.	Similar to NED, but effects will extend for a 6-year period of construction resulting in additional RED benefits. Major population and economic centers will have reduced risk of flooding resulting in faster regional recovery.
D. Other Social Effects (OSE) – Life Safety Evaluation Metrics			
1. Life, Health, and Safety	Continued flood risk and consequences in the Sutter Basin including the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Significant life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs are significantly reduced.
1a.Remaining Population at Risk	Approximately **94,600** individuals are within the 1% ACE floodplain.	**38,200** people remain in the 1% ACE floodplain. (60% of population is removed from the 1% ACE residual floodplain for NED.)	**6,600** people remain in the 1% ACE floodplain. (93% of population is removed from the 1% ACE residual floodplain for SB-8)
1b. Loss of Life Estimate For 1% ACE event (Based on Hurricane Katrina loss of life ratio)	Potential loss of **112** lives.	Potential loss of **45** lives.	Potential loss of **8** lives.
1c. Critical Infrastructure – Life Safety	**28** structure deemed as critical from a national perspective are at risk from floods.	**11** structures remain at risk from floods.	**1** structure is at risk from floods.
1d. Evacuation Routes (See comparative plates below)	In the event of a flood, no evacuation route is available out of the basin.	Offers **one** problematic route for evacuation during a flood event. A flood warning and evacuation plan would not be as effective and limited.	**5** evacuation routes are available in the event of a flood. A flood warning and evacuation plan would have more robustness and redundancy.

	NO ACTION	NED PLAN	LPP PLAN
1e. Wise Use of Floodplains Note: fix-in-place measures are only bringing levees up to authorized elevation and performance.	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development. (additional 12,000 potential acres calculated compared to NED)
2. Social Vulnerability (Study Area Resiliency)	The social vulnerability index score (SoVi) indicates the study area to be medium to high vulnerability. The No Action alternative may leave communities unable to cope with the recovery from a flood hazard.	Majority of the community of Yuba City is afforded flood risk reduction, however the communities of Live Oak, Gridley, and Biggs remain at risk of flood hazards and may be unable to cope and recover.	The four existing communities are provided flood risk reduction, and social vulnerability is minimized due to a decrease in the probability of flood hazards occurring.
3. Residual Risk and Consequences	Residual Risk remains high throughout the study area	Residual Risk for Life Safety is reduced for most of the Yuba City urban area.	Residual Risk for Life Safety is reduced in the high risk communities: Yuba City, Live Oak, Gridley and Biggs.
E. Federal Planning Criteria			
Acceptability	N/A	The local sponsors and public support levee fixes and improvements.	The local sponsors and public support levee fixes and improvements.
Effectiveness	N/A	Addresses the primary planning objectives of reducing FRM and some life safety.	Addresses the primary planning objectives of reducing FRM and life safety.
Efficiency	N/A	Economic analysis and outputs identified	Economic analysis and outputs identified
Completeness	N/A	Significant residual risk of life safety in the northern basin communities of Biggs, Gridley, and Live Oaks.	Reduces residual risk of life safety to Yuba City and the communities of Biggs, Gridley, and Live Oaks.

Alternative Comparison.

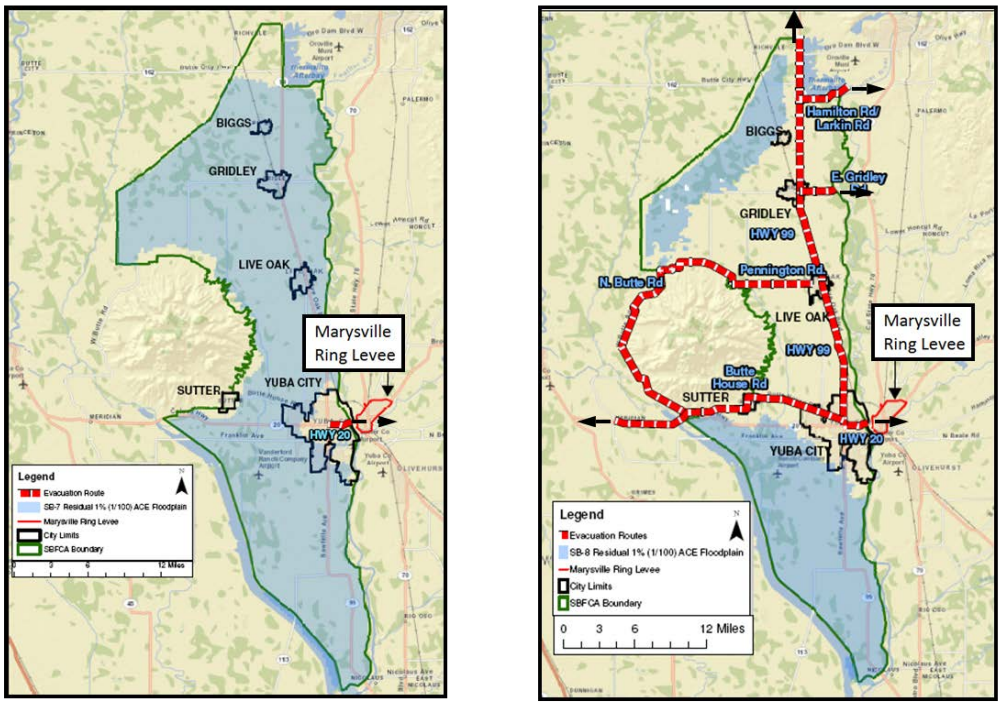
Population at Risk. A more specific comparison figures were developed in comparing the NED plan with the LPP (SB-8). The NED plan removed 60% of the basin population out of the 1% ACE floodplain while the LPP (SB-8) removed 93% of the basin population out of the 1% ACE floodplain. (See Table 11)

Table 11: Remaining Population at Risk

Community	NED Population Remaining at Risk	SB-8 Population Remaining at Risk	Reduction of Population at Risk
Yuba City	11,400	3,500	7,900
Biggs	1,500	20	1,480
Gridley	6,400	0	6,400
Live Oak	8,400	0	8,400
Sutter Rural	5,800	3,100	2,700
Butte Rural	4,800	20	4,780
Total	**38,200**	**6,600**	**31,600**

Evacuation Routes. The availability and access of evacuation route options tied to the sudden unpredictable nature of recent flood events is a critical comparison factor of the NED vs. to the LPP. With the population centers spread throughout the middle and northern sections of the Basin, having multiple routes to choose from is critical to evacuation planning and real time evacuation. Adjoining basins to the southwest, south, and east, either has lower levels of flood protection or is surrounded by water during flood events, making them dangerous locations for evacuees. The NED plan provides only one route to the city of Marysville which has historically been surrounded by water in flood events and is currently in final planning stages for a ring levee FRM project. (Figure 8).

Figure 8. Comparison of NED and LPP Evacuation Routes (1% ACE Residual Floodplains)

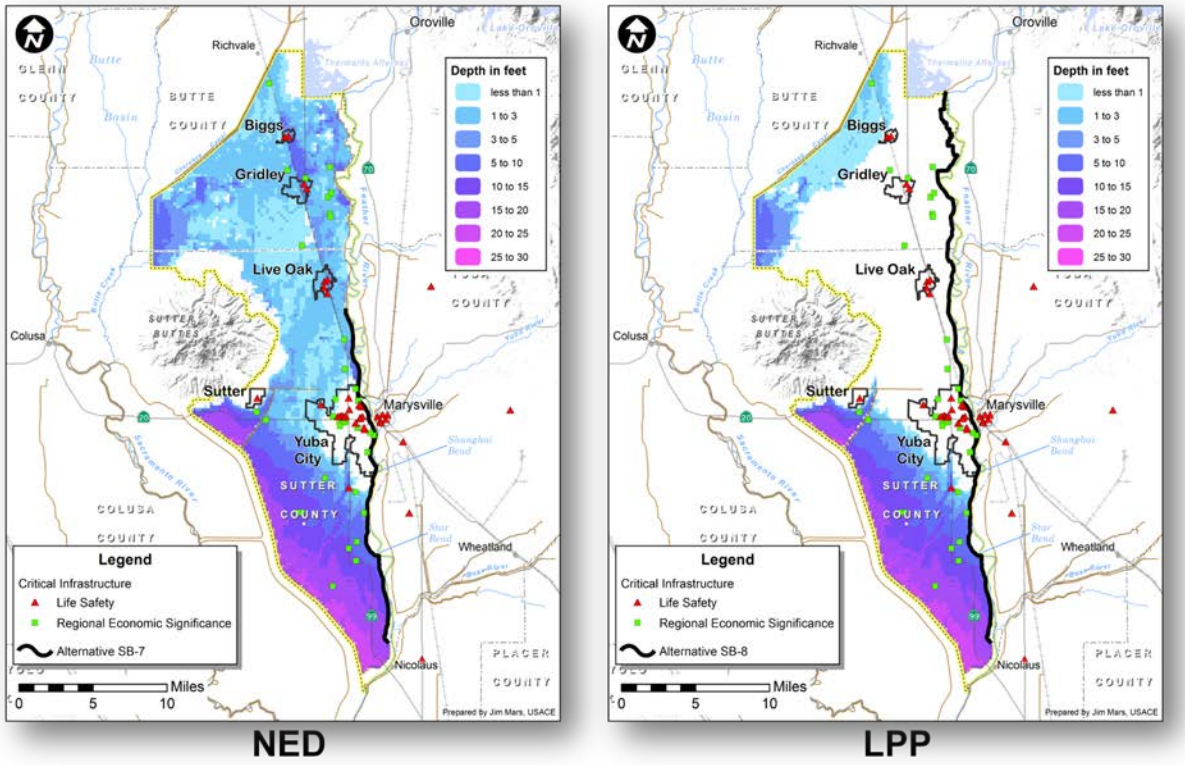


NED LPP

Critical Infrastructure. In terms of response and recovery of flood events for life safety, the NED plan leaves numerous critical infrastructure facilities at in the 1% ACE residual floodplain in the cities of Biggs, Gridley, Live Oak, and part of Yuba City (Figure 9). A partial list is provided here:

- 1 Hospital (45 beds)
- 2 Police stations
- 5 Fire stations
- 1 Assisted living center (99 beds)
- 3 City hall buildings
- 1 Correctional Facility (305 inmate capacity)
- 3 Water and sewer treatment facilities
- Multiple telecommunication facilities

Figure 9. Critical Infrastructure-Life Safety Comparison

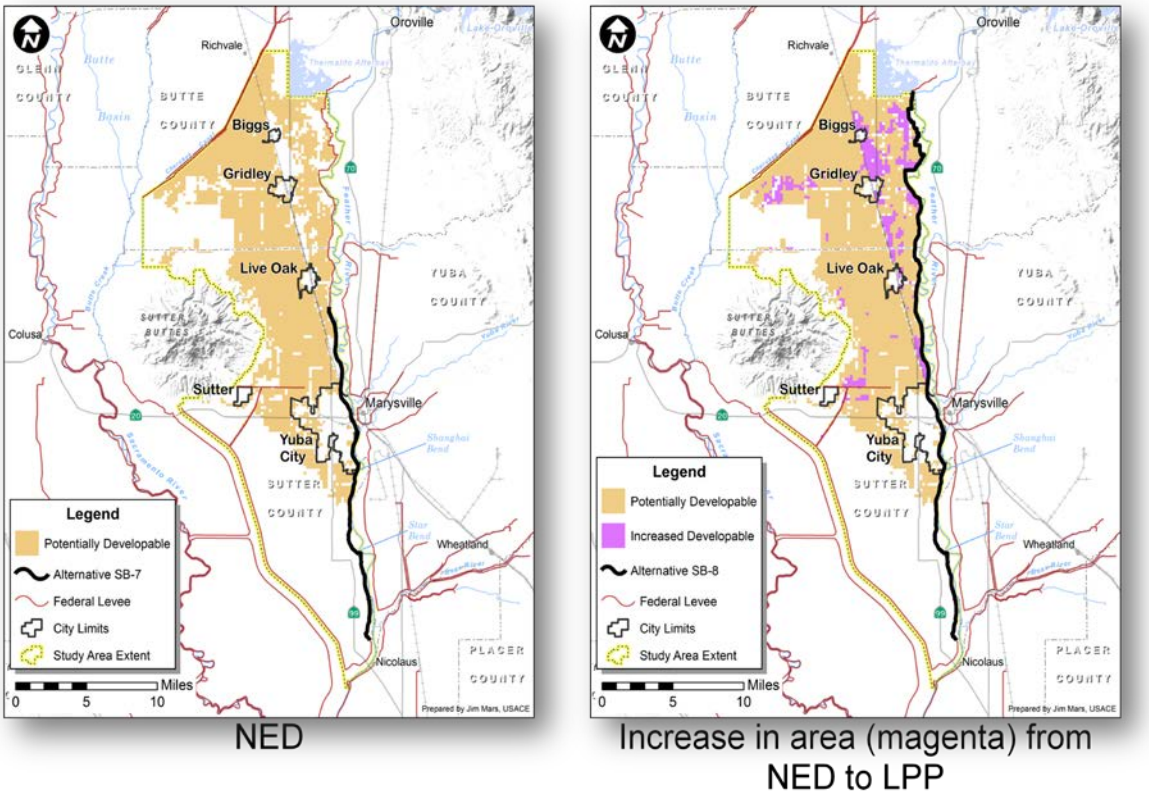


Wise Use of Floodplains. Potentially developable land in terms of 1% ACE residual floodplains were calculated as an evaluation metric to enable general comparison of potentially developable floodplain under the NED Plan vs. the LPP assuming land is developable if the 1% ACE floodplain depths are 3-feet or less (Figure 10). The calculation estimates the potential of roughly 12,000 additional acres made available with the LPP vs. the NED plan. The LPP includes conservation easements that could be purchased by the local sponsor to mitigate potential residual loss of life. See Attachment 1, slides 59-60.

Sutter Basin is an agriculturally focused region. The local and state partners have several existing land use commitments and constraints in the Sutter Basin in regards to development in the floodplain:

- Williamson Act Contracts: These rolling 10-year agreements between government and farmers to preserve the agricultural and open space in rural California by offering landowners tax breaks on the assessed land value.
- Conservation Easements: Agreements between landowners and an agency (USFWS, etc) which permanently precludes future development.
- Flood Risk Notifications: Annual flood risk notifications sent to all property owners.

Figure 10: Potentially Developable Floodplain Comparison



Loss of Life. Estimates of potential loss of life were made for this study for areas identified as rescue areas and for the areas identified as evacuation area. These estimates are based upon actual loss of life ratios experienced in 2005 by the population of New Orleans during the Hurricane Katrina levee failures. Boyd et al. assumed that of the inhabitants in a flooded area, 80% evacuated and 10% found shelter in a specialty facility (such as the Superdome or high school), leaving approximately 10% of the population in a flooded area exposed to the flood event. Based on actual fatalities in New Orleans a mortality rate of 1.18% was determined for the population exposed to the flood event.

As indicated in Table 12, application of the Katrina ratio to the approximately 94,800 population within the No Action population at risk associated with a Feather River levee failure results in the potential loss of 112 lives, to the approximately 38,300 people within the NED residual floodplain results in the potential loss of 45 lives, to the approximately 6,640 people in Alternative SB-8 residual floodplain results in the potential loss of 8 lives. Note that these are preliminary values. Many factors will influence the mortality rate from a flooding disaster, including timing of the breach (day or night), population located near the breach, and availability of flood warning and evacuation routes. The preliminary analysis provides an indication of the loss of life lives that might be expected. In the California Central Valley, the risk of a large flood is seasonal. The majority of rainfall occurs in the November through March rainy season, making the area most vulnerable to winter floods. Standing or working in water which is cooler than 75 °F (24 °C) will remove body heat more rapidly than it can be replaced, resulting in hypothermia. Cold water removes heat from the body 25 times faster than cold air. About 50% of that heat loss occurs through the head. Physical activity such as swimming or other struggling in the water increases heat loss.

Hypothermia (decreased body temperature) develops more slowly than the immediate effects of cold shock. Survival curves show that an adult dressed in average clothing may remain conscious for an hour at 40 °F and perhaps 2-3 hours at 50 °F (water temp.). Any movement in the water accelerates heat loss. Survival time can be reduced to minutes. Hands rapidly become numb and useless. Without thermal protection, swimming is not possible. The victim, though conscious, is soon helpless. Without a life jacket, drowning is unavoidable.

Table 12: Estimated Loss of Life (1% ACE Residual Floodplain)

Economic Impact Area	Estimated Loss of Life		
	No Action	NED (SB-7)	LPP (SB-8)
Biggs	2	2	0
Gridley	8	8	0
Live Oak	10	10	0
Yuba City	80	13	4
Rural Butte	6	6	0
Rural Sutter	7	7	4
Total	112	45	8

Other Alternative Comparison Considerations and Factors.

Levee Safety Program – Baseline Conditions Risk Assessment. Levee Safety Program – Baseline Conditions Risk Assessment (BCRA). The Sutter Basin area is one of five areas selected to undergo a risk assessment by the USACE Risk Management Center (RMC). Within the Levee Safety Program framework, the BCRA is a quantitative risk assessment to advance the goal of the Levee Safety Program to work with stakeholders to assess, communicate, reduce, and manage risk associated with levee systems.

The Sutter Basin BCRA will include risk assessments of the baseline (existing conditions). Data collected as part of the Sutter Basin Feasibility study will be used by the RMC to assist in the development of the baseline. Once the baseline is established the RMC will evaluate the NED and LPP alternatives developed during the Sutter Study. The risk will be characterized by the combination of the probabilities of failure estimated for each failure mode and the consequences (life loss and damages) associated with that failure. Risk will be reported in terms of annualized life loss and estimated annual damages. Preliminary results are expected to be available in the spring of 2013.

Executive Order 11988. The objective of the Sutter Basin study is to reduce flood risk within the study area. The study is responsive to the EO 11988 objective of "avoidance, to the extent possible, of long- and short-term adverse impacts associated with the occupancy and modification of the base flood plain and the avoidance of direct and indirect support of development in the base flood plain wherever there is a practicable alternative". The proposed features focus on reducing the threat of flooding to the existing urban areas, altering a scattered footprint difference between the NED and LPP within the northern floodplain (Figure 10). These features would reduce the hazard and risk associated with floods thereby minimizing the effects of floods on life safety, health, and welfare to the existing population, and would preserve the natural and beneficial values of the base floodplain. For these reasons the proposed plan is in compliance with EO 11988.

Emergency Costs and Evacuation Planning. NED losses associated with public goods and services include some of the costs incurred as part of actions required to respond to a flood emergency. The type of costs that could be incurred and considered NED losses are those associated with the following activities, which may employ staff and equipment:

- Structure clean-up: monetary damages associated with the removal of debris generated by damage structures due to flooding
- Displacement: temporary relocation of residents, and subsistence costs (incremental costs above those that would be normally incurred)
- Public assistance/emergency response services

An expert-opinion elicitation panel comprised of professionals having significant, relevant experience in the field of emergency response convened in Sacramento, CA (2009) with the goal of developing estimates of the economic cost associated with various emergency related damage categories (evacuation, debris activities, public services, utilities, etc) . Initial modeling results for district studies, as a proportion of structure and content damages, ranged from 1-3%.

Additionally, road damages and traffic-related costs associated with detours and extra time traveled by motorists due to potential flooding in the Sutter Basin was forgone based on prior experiences, which have shown such damage categories to be relatively minimal when compared to structural damages. Nevertheless, it is recognized that in order to detail the magnitude of flooding problems in the Sutter Basin, the economic analyses can be conducted. However, because these damages categories are not expected to drive plan selection it was omitted from the analysis. If deemed necessary, emergency costs, road damages and traffic disruption analyses can be conducted during refinement of tentatively selected plan (TSP).

Non-Federal Sponsors' Request.

Sutter Butte Flood Control Agency and the State's California Central Valley Flood Protection Board are the non-Federal sponsor for the Pilot Feasibility Study. The LPP Plan is supported by both the non-Federal sponsors as this plan addresses the flood risk of Yuba City and the residual flood risk and consequences of life safety to the existing cities of Biggs, Gridley, Live Oaks, and parts of Yuba City that the NED Plan does not. The non-Federal sponsors agree to pay for the determined cost share of the LPP.

The LPP also meets the requirements of Senate Bill (SB) 5 which stipulates that urban and urbanizing areas of 10,000 or greater must achieve 1/200 ACE level of flood risk management. It should be noted that the southern deeper part of the basin would remain in the 1/100 ACE floodplain.

TSP Recommendation. The multi-objective comparison and assessment between the NED Plan and the LPP are summarized in Table 10. Both the NED and LPP provide significant benefits that exceed the costs. While the NED Plan is more efficient than the LPP, both plans are efficient. Both the NED and LPP are complete since they each contain all necessary elements for the project to function independently. In a multi-objective context that equably emphasizes flood risk reduction and residual risk to life safety across all accounts and criteria, the LPP can be recommended as the Tentatively Selected Plan.

8. RECOMMENDATION OF THE TSP

Both the NED (SB-7) and the LPP (SB-8) provide significant benefits that exceed the costs. While the NED Plan is more efficient than the LPP, both plans are efficient (B/C >1). Both plans are complete in that they include all necessary elements needed for the project to function without relying on other activities. The LPP plan is more effective in that it provides greater flood risk reduction benefits and addresses residual risk of life safety within the Sutter Basin. Based upon the information developed in support of the Decision Point 2 Conference, and the conclusions that can be drawn from that information and were presented to the Vertical Team, the LPP (SB-8) will be recommended as the Tentatively Selected Plan (TSP) in the Draft Feasibility Report.

Cost Sharing. Table 13 presents two cost sharing scenarios for Federal/non-Federal cost allocation for the TSP: full Federal participation as established by Section 103 of WRDA 1986; limited Federal participation where the Federal share is limited to the Federal share of the NED alternative. The range in confidence of cost estimates are displayed in Table 6, the mean estimates are used in the table below.

Table 13. Cost Allocation Scenarios for TSP ($1,000)[11]

Cost Allocation	NED	LPP	
		Full Federal Participation	Limited Federal Participation
Non-Federal			
LERRD	$48,333	$71,073	$71,073
Cash	$99,717	$178,477	$366,977
Sub Total	$148,050	$249,550	$438,050
Federal			
Construction	$274,950	$463,450	$274,950
Total Project Cost	$423,000	$713,000	$713,000

Full Federal Cost Participation. The estimated total project first cost for the TSP is $713 million, with an estimated Federal cost of $463 million and a non-federal cost of $250 million.

Limited Cost Share. The estimated total project first cost for the TSP is $713 million. Federal costs are capped at 65% of the NED plan ($275million) with an estimated to non- federal cost $438 million.

Recommendation.

The recommendation for the tentatively selected plan is the LPP Alternative. To recommend the LPP as the TSP, a Policy Exception Request will be developed and forwarded to the ASA (CW). With a confirmation of a recommended TSP, the PDT is scheduled to move forward in refining and finalizing an integrated draft EIS/EIR-feasibility report for concurrent public, internal and external peer reviews.

[11] LERRDs are based preliminary estimates based screening level cost estimates.

9. SUMMARY

- Recent geotechnical analysis of project levees reveal significant adverse flooding impacts as a result of underseepage failures, which are sudden and unpredictable, resulting in minimal warning time, and ineffectiveness of evacuation plans.

- The total value of damageable property within the Sutter Basin study area is estimated at $6.9 billion.

- Management measures were developed and formed the basis of the preliminary alternatives, which were evaluated and resulted in a draft array of alternatives of which SB-7 was identified as the NED Alternative, affirming federal project interest.

- The NED residual 1% ACE floodplain showed significant adverse flooding impacts remained given that the alternative only addressed flooding impacts in one of the four existing communities.

- An assessment of the residual risk of the NED Alternative using life safety metrics served to illustrate the magnitude of the flooding impacts. The metrics were population at risk, critical infrastructure, availability of evacuation routes and the potential developable acres.

- With the aim of buying down the residual risk, the PDT found the most cost-effective incremental alternative to the NED to be Alternative SB-8.

- The additional investment of $290 million in project cost (Alternative SB-8 first cost minus the NED Alternative cost) buys down the residual risk of the NED Alternative and provides significant non-monetized benefits. Total annual benefits increase from $51 to $58 million. The population at risk of flooding from a 1% ACE flood event decreases from 38,200 to 6,600, critical infrastructure at risk (within the 1% ACE floodplain) is reduced from 11 to 1, and the number of evacuation routes increases from 1 to 5. A preliminary estimate of the potential loss of life indicates a substantial reduction from 45 lives (NED) to 8 lives (LPP).

- The wise use of floodplain metric used in the analysis is a simple index based on physical parameters, and does not account for current restrictive zoning ordinances, which govern and limit future development.

- The final array of alternatives includes the No Action, NED and LPP.

- The LPP (Alternative SB-8) is recommended as the TSP that comprehensively addresses flood risk and the residual risk to life safety and is the federal plan.

CESPK-PD-W 28 November 2012

MEMORANDUM FOR FILE

SUBJECT: Sutter Basin Pilot Feasibility Study; Multi-Objective Analysis of Flood Risk Management Alternatives

1. References:

a. Recommendations for Transforming the Current Pre-Authorization Study Process, USACE, January 2011
b. Sutter Basin Pilot Study Draft Re-Scoping Plan, 1 September 2011
c. Developing a Feasibility Study with Multiple Planning Objectives, 31 May 2012, SMART Guide, planning.usace.army.mil/toolbox/

2. Purpose

The purpose of this memorandum is to describe the multi-objective analysis used for the evaluation and comparison of the final array of alternatives, and for the selection of the tentatively recommended plan.

3. Background

The Sutter Basin Feasibility Study was selected as a Planning Modernization pilot study to test principles that have been outlined in the *USACE Recommendations for Transforming the Current Pre-Authorization Study Process* (January 2011) and associated materials. One of the five key elements highlighted by the *Recommendations* is the use of a multi-criteria approach to alternative selection, including moving away from the rote acceptance of National Economic Development (NED) or National Ecosystem Restoration (NER) as the sole criterion for plan selection. This element of the *Recommendations* also suggests the use of less detailed quantitative analysis and more judgment, including the use of weighted criteria. These *Recommendations* were based on the recognition of shortcomings in past practices, as well as anticipation of the proposed *Principles and Requirements.*

The *Sutter Basin Pilot Study Re-scoping Plan* (Reference 1.b) stated that it was anticipated that evaluation and comparison of the final array of alternatives would be based on monetary and non-monetary effects, qualitative and quantitative data, and economic, public safety, environmental, and regional criteria. The final array of alternatives would be evaluated and compared through a comprehensive trade-off analysis, which might involve unequal weighting of criteria. The alternative with the greatest net benefits would be identified; but may not be chosen as the Tentatively Selected Plan (TSP) based on the results of the trade-off analysis.

4. Approach

The evaluation criteria identified in the *Re-scoping Plan* were based on both existing Corps policy, including the *Principles and Guidelines (P&G)* and *Planning Guidance Notebook (PGN)*, and the proposed *Principles and Requirements (P&R).* Pursuant to the *Recommendations*, the Sutter pilot study team developed a multi-objective approach to plan evaluation and selection that would consider all of the planning objectives identified for the study, rather than only the NED and NER objectives.

The Planning Objectives identified in the *Re-scoping Plan* are:

- Reduce the risk to life, health, and public safety due to flooding.
- Reduce the risk of property damage due to flooding.
- Reduce the risk of damage to critical infrastructure due to flooding.
- Encourage wise use of the floodplain.
- In conjunction with Flood Risk Management (FRM), restore floodplain connectivity and associated dynamic riverine processes.
- In conjunction with FRM, restore aquatic, wetland, riparian, and terrestrial habitats for special status and other native species.
- In conjunction with FRM and ER, improve the public's access to and use of outdoor recreational opportunities in the study area.
- Additional Non-Federal Sponsor Objective: Reduce the probability of flooding to urban and urbanizing areas to less than 0.5 (1/200) Annual Chance Exceedance with assurance..

5. Evaluation Criteria

The Project Delivery Team (PDT) decided the evaluation criteria for the multi-objective analysis should focus on the first four objectives, which are the FRM objectives. The ER and Recreation objectives are secondary to FRM and therefore are best considered as additions to the TSP. Alternatives that would fulfill the additional Non-Federal Sponsor Objective for FRM were included in the preliminary alternatives to allow potential identification of a Locally Preferred Plan (LPP) by the sponsor.

The PDT also selected evaluation criteria that would identify significant differences between the preliminary alternatives. Some potential criteria that were considered, including environmental justice, were not selected because initial evaluations did not indicate significant differences among the preliminary alternatives.

The PDT initially selected the following evaluation criteria/metrics:

a. NED Costs
b. NED Benefits
c. Annualized Population at Risk
d. Critical Infrastructure – Life Safety
e. Critical Infrastructure – Regional
f. Wise Use of Floodplain

g. Environmental Effects
h. Ecosystem Restoration

The definitions of the specific metrics for these criteria, and the processes by which they were quantified, are detailed in separate memoranda.

After the metrics had been quantified, the PDT decided that two of the metrics should not be used in the multi-objective analysis. The ecosystem restoration metric was not used because all of the potential ecosystem restoration measures under consideration were separable from the FRM measures. The critical infrastructure - regional metric was not used because nearly all of the identified facilities were agricultural processing facilities that were not likely to be active during the flood season and that were also included in the NED benefit metric.

6. Multi-Objective Analysis: Alternate Methods Applied

Several methods of multi-objective analysis were tested to identify a method that would be informative and transparent. These methods were based in part on concepts presented in the Planning SMART Guide (Reference 1.c), as well as discussions within the task group that addressed multiple-objective planning for the Planning SMART initiative.

a. Method A: Cost Effectiveness and Incremental Cost Analyses Using Weighted Criteria

Method A used modified Cost Effectiveness and Incremental Cost Analyses (CE/ICA) based on the standard Corps methodology for optimizing mitigation and restoration plans. This method was intended to allow incremental benefits to be compared to incremental costs in an optimization process. The net values of five output metrics (b, c, d, f and g in Item 5, above) for the eight preliminary alternatives were normalized to a scale of 0 to 1 using the percent of maximum method. In each case, a normalized value of 1.00 was assigned to the most beneficial (or least adverse) net output and a normalized value of 0.00 was the least beneficial net output. See Table 1 for the calculation of the normalized values for the six alternatives.

Rather than selecting a single set of weights for the five output criteria, the PDT decided to apply different sets of weights (i.e., multiple weightings) as a sensitivity analysis. If a single alternative was cost-effective, or very few alternatives were cost-effective, across a reasonable range of weightings, that result would provide a basis for plan selection. A wide range of potential weightings was tested using this modified CE/ICA method. Certified IWR Planning Suite software was used to perform CE/ICA.

In this study, the modified CE/ICA method did not provide results that could easily be used to select a plan. The lack of a clear result was partially due to the lack of an objective basis for judging the maximum incremental cost that would be justified for a mixture of various outputs. In addition, the ICA method compares outputs to costs, similar to a benefit-to-cost ratio. Although that process identifies the relative cost-efficiency of the alternatives, it does not identify which alternative produces the greatest net beneficial outputs, which would be more consistent with the Corps' national planning objectives. Consequently, when there are large differences in the scales of alternatives, the ICA method tends to favor smaller, more cost-

Table 1. Normalization of Values for Metrics

Alternative	Economic Benefits		Life Safety					Critical Infrastructure			Environmental Effects		Wise Use of Floodplain			Cost	
			Population at Risk			Evacuation Routes		Life Safety Facilities			Project Footprint		Potentially Developable Floodplain Area				
	($Mil Annual)		(Total Pop in 1% Floodplain)			(Number - Low Risk)		(Number at Risk)			(Acres)		(Acres)			($Mil Annual)	
	Gross	Normal	Gross	Net	Normal	Gross	Normal	Gross	Net	Normal	Gross	Normal	Gross	Net	Normal	Gross	Normal
SB-1: No Action	0	0.00	94618	0	0.00	0	0.00	28	0	0.00	0	1.00	71,832	0	1.00	0	0.00
SB-2: Minimal Fix-in-Place	38	0.51	56686	37932	0.40	1	0.20	10	18	0.64	22	0.89	83,770	11,938	0.84	16	-0.26
SB-3: Yuba City Ring Levee	41	0.55	27250	67368	0.71	1	0.20	9	19	0.68	194	0.00	79,339	7,507	0.90	24	-0.39
SB-4: Little J Levee	46	0.62	3783	90835	0.96	2	0.40	1	27	0.96	174	0.10	101,309	29,477	0.60	42	-0.68
SB-5: Fix-in-Place, Thermalito to Star Bend	45	0.61	27647	66971	0.71	3	0.60	1	27	0.96	33	0.83	95,661	23,829	0.68	32	-0.52
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal	74	1.00	101	94517	1.00	5	1.00	0	28	1.00	50	0.74	146,006	74,174	0.00	62	-1.00
SB-7: Fix-in-Place, Sunset Weir to Laurel Avenue	51	0.69	38209	56409	0.60	1	0.20	10	18	0.64	27	0.86	88,223	16,391	0.78	22	-0.35
SB-8: Fix-in-place, Themalito to Laurel Avenue	58	0.78	6648	87970	0.93	3	0.60	1	27	0.96	39	0.80	100,230	28,398	0.62	39	-0.63

efficient alternatives, such as Alternatives SB-2 and SB-7. Because the results of Method A were not consistent with the objective of maximizing net beneficial effects, the details of those results are not presented here.

In this study, the modified CE/ICA method did not provide results that could easily be used to select a plan. The lack of a clear result was partially due to the lack of an objective basis for judging the maximum incremental cost that would be justified for a mixture of various outputs. In addition, the ICA method compares outputs to costs, similar to a benefit-to-cost ratio. Although that process identifies the relative cost-efficiency of the alternatives, it does not identify which alternative produces the greatest net beneficial outputs, which would be more consistent with the Corps' national planning objectives. Consequently, when there are large differences in the scales of alternatives, the ICA method tends to favor smaller, more cost-efficient alternatives, such as Alternatives SB-2 and SB-7. Because the results of Method A were not consistent with the objective of maximizing net beneficial effects, the details of those results are not presented here.

b. Method B: Multi-Criteria Decision Analysis

In an effort to avoid the shortcomings of the CE/ICA approach, use of a Multi-Criteria Decision Analysis was tested. The same normalized values were used as in Method A (Table 1), but with the addition of NED Costs as an additional criterion. Techniques that were used for the trade-off analysis in the 2004 Hamilton City feasibility report were applied to this study. Those techniques included assigning a negative normalized value to costs, so that the ultimate total weighted product calculated for each alternative represents a net combined output (i.e., beneficial effects minus cost). Another specific technique used was to assign weights to NED costs and NED benefits in the same ratio as the ratio of the maximum NED costs to the maximum NED benefits. Because the raw benefit and cost values were normalized using the percent of maximum method, the use of the ratio of maximum values to select the weights for benefits and costs ensures that dollars of costs and dollars of benefits are weighted equally in the trade-off analysis. This technique avoids significant distortions that can otherwise easily occur due to the weighting process.

As in Method A, rather than selecting a single set of weights for the five output criteria, the PDT decided to apply different sets of weights (i.e., multiple weightings) as a sensitivity analysis. Table 2 illustrates various results from multi-criteria decision analyses using different sets of weights.

Scenarios 1A-1D show the results of varying the weights for NED costs and benefits from maximum to low levels, while assigning equal weight to the other four criteria. If only NED benefits and costs are considered (Scenario 1A), then the result is that Alternatives SB-7 is preferred over all of the other alternatives. If the additional non-NED criteria are given even weights (Scenarios 1B-1D), then the result is that Alternative SB-7 is still preferred until the total weight assigned to NED benefits and costs is reduced to below 60%. With less than 60% weight assigned to the NED criteria, and the remaining greater-than-40% weight evenly distributed among the remaining four criteria (Scenario 1D), Alternative SB-8 is preferred.

Table 2. Selected Examples of Multi-Criteria Decision Analysis Using Various Weightings

	WEIGHTS (PREFERENCES)								WEIGHTED PRODUCTS							COMMENTS
Scenario	**Benefits**	**LS Pop**	**LS Evac**	**Critical**	**Environ**	**Floodplain**	**Cost**	**Total**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**	**Alt 6**	**Alt 7**	**Alt 8**	
1A	54%	0%	0%	0%	0%	0%	46%	100%	0.16	0.13	0.03	0.10	0.09	**0.21**	0.14	NED Only
1B	50%	1%	1%	2%	2%	2%	42%	100%	0.20	0.16	0.07	0.15	0.14	**0.25**	0.19	Even weights for non-NED
1C	40%	3%	3%	7%	6%	7%	34%	100%	0.29	0.23	0.18	0.27	0.24	**0.33**	0.31	Even weights for non-NED
1D	32%	6%	5%	10%	10%	10%	27%	100%	0.37	0.28	0.26	0.38	0.34	0.40	**0.41**	Even weights for non-NED
2A	35%	9%	9%	18%	0%	0%	29%	100%	0.27	0.28	0.31	0.35	**0.42**	0.32	0.40	Life safety very heavily weighted
2B	35%	8%	9%	9%	5%	5%	29%	100%	0.30	0.26	0.25	0.33	0.35	0.34	**0.38**	Life safety moderately weighted
3A	35%	0%	0%	0%	0%	36%	29%	100%	0.41	0.40	0.24	0.31	0.06	**0.42**	0.31	Floodplain very heavily weighted

Notes: **Bold** indicates preferred alternatives based on indicated weighting. For Scenario 1 only, Population at Risk and Evacuation metrics are combined in the Life Safety criterion to avoid double-weighting of life safety factors.

Of course, alternatives other than Alternatives SB-7 or SB-8 can be preferred depending upon the weights that are assigned to the selection criteria. Scenario 2A shows that Alternative SB-6 is favored if a relatively high weight is given to the three criteria related to Life Safety, including Critical Infrastructure. However, if the Critical Infrastructure criterion is more moderately weighted with moderate weights given to the other criteria (Scenario 2B), then Alternative SB-8 is preferred.

Scenario 3A shows that Alternative SB-7 is favored even if a relatively high weight is given to the Floodplain criterion.

c. Method C: Pair-wise Comparison

Because the Method B Multi-Criteria Decision Analysis resulted in multiple top-ranked plans based upon a reasonable range of weightings, a pair-wise comparison was used to highlight the significant differences between pairs of alternatives. Because recommendation of the NED Plan is the Corps norm, any other alternative must be compared to the NED Plan and found to be superior in order to be recommended as the Federal Interest Plan. Consequently, the use of pair-wise comparison is a good fit with the Corps' current planning policies.

In this study, pair-wise comparison was used to address the following question:

- Should a plan other than the NED Plan be recommended as the Federal Interest Plan based on consideration of all four P&G accounts?

This question was addressed by comparing alternative plans (Alternatives SB-2, SB-3, SB-4, SB-5, SB-6, and SB-8) to the NED Plan (Alternative SB-7).

Table 3. Alternative SB-2 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-2	319	16	38	22	37932	1	18	22	11,938
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	-104	-6	-13	-7	-18477	0	0	-5	-4,453
% Diff	**-25%**	**-27%**	**-25%**	**-24%**	**-33%**	**0%**	**0%**	**-19%**	**-27%**

Alternative SB-2 can be considered the first increment, as it is the smallest increment and is contained within all of the other alternatives. Alternative SB-2 significantly reduces net benefits compared to Alternative SB-7 while minimally reducing environmental effects and providing a smaller reduction in the population at risk. However, Alternative SB-2 substantially reduces the acreage of potentially developable floodplain. If the potential floodplain development effects of Alternative SB-7 are considered to be acceptable, or can be avoided or mitigated to an acceptable level, then there would be no reason to consider recommending Alternative SB-2 rather than Alternative SB-7.

Table 4. Alternative SB-3 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-3	451	24	41	17	67368	1	19	194	7,507
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	28	2	-10	-12	10959	0	1	167	-8,884
% Diff	**7%**	**9%**	**-20%**	**-41%**	**19%**	**0%**	**6%**	**619%**	**-54%**

When compared to Alternative SB-7, Alternative SB-3 provides substantially less net NED benefit and has a significantly larger environmental effects footprint. The major advantages of Alternative SB-3 are reductions in the population at risk and the acreage of potentially developable floodplain.

Table 5. Alternative SB-4 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-4	798	42	46	4	90835	2	27	174	29,477
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	375	20	-5	-25	34426	1	9	147	13,086
% Diff	**89%**	**91%**	**-10%**	**-86%**	**61%**	**100%**	**50%**	**544%**	**80%**

Alternative SB-4 provides substantially lower net NED benefits compared to Alternative SB-7, but performs significantly better than Alternative SB-7 for life safety and critical infrastructure criteria. Alternative SB-4 would have a significantly larger environmental effects footprint and a significantly larger increase in the potentially developable floodplain area compared to Alternative SB-7.

Table 6. Alternative SB-5 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-5	608	32	45	13	66971	3	27	33	23,829
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	185	10	-6	-16	10562	2	9	6	7,438
% Diff	**44%**	**45%**	**-12%**	**-55%**	**19%**	**200%**	**50%**	**22%**	**45%**

The major advantages of Alternative SB-5 over Alternative SB-7 are the increases in all life safety/critical infrastructure criteria. However, Alternative SB-5 would result in a significant decrease in net NED, while having a greater environmental effect footprint and a greater increase in the potentially developable floodplain.

Table 7. Alternative SB-6 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-6	1131	62	74	12	94517	5	28	50	74,174
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	708	40	23	-17	38108	4	10	23	57,783
% Diff	**167%**	**182%**	**45%**	**-59%**	**68%**	**400%**	**56%**	**85%**	**353%**

Costs for Alternative SB-6 are nearly three times as much as for Alternative SB-7, but the flood risk reduction benefits are only 45% higher; as a result, the net NED benefits for Alternative SB-6 are significantly lower than for Alternative SB-7. Alternative SB-6 would reduce the population at risk by an additional 68%, remove 10 additional critical infrastructure facilities from the 1% annual chance floodplain, and provide four more evacuation routes than Alternative SB-7. Alternative SB-6 has a larger environmental effects footprint than Alternative SB-7. A prominent difference between the two alternatives is that Alternative SB-6 would increase the potentially developable floodplain area by over three times as much as Alternative SB-7. In order for Alternative SB-6 to be recommended over Alternative SB-7, a very high value would have to be placed on the additional life safety/critical infrastructure outputs provided by Alternative SB-6 to offset the disadvantages of Alternative SB-6 due to its much higher costs, lower net NED benefits, and much greater increase in potentially developable floodplain area.

Table 8. Alternative SB-8 versus Alternative SB-7

	Costs		Beneficial					Adverse	
	First Cost	Ann Cost	Ann Ben	Net Ben	Decrease in Pop at Risk	Evacuation	Critical Inf	Env Effect	Floodplain
Alt SB-8	713	39	58	19	87970	3	27	39	28,398
Alt SB-7	423	22	51	29	56409	1	18	27	16,391
Diff	290	17	7	-10	31561	2	9	12	12,007
% Diff	**69%**	**77%**	**14%**	**-34%**	**56%**	**200%**	**50%**	**44%**	**73%**

Alternative SB-8 would triple the number of evacuations routes, reduce the population at risk by an additional 56%, and remove 9 additional critical infrastructure facilities from the 1% annual chance floodplain, at a 77% higher cost than Alternative SB-7. Alternative SB-8 increases the environmental effects footprint and potentially developable floodplain area compared to Alternative SB-7. If the increases in life safety/critical infrastructure criteria are considered to outweigh the increase in costs, reduction in net benefits, and increases in adverse effects, then Alternative SB-8 would be preferred over Alternative SB-7.

7. Conclusions

Several methods of multi-objective analysis were applied to the Sutter Basin alternatives:

Method A (Cost Effectiveness and Incremental Cost Analyses Using Weighted Criteria) did not indicate a clear choice among the alternatives due to the lack of an objective basis for judging the maximum incremental cost that would be justified for a mixture of various outputs.

Method B (Multi-Criteria Decision Analysis) demonstrated that Alternative SB-7 is the preferred alternative over the widest range of relatively balanced weightings, or if the floodplain criterion

is heavily weighted. Method B also demonstrated that other alternatives would be favored if certain criteria were heavily weighted along with the NED benefit and cost criteria. Alternative SB-6 is favored if the three life safety criteria (evacuation, critical infrastructure, and population at risk) are heavily weighted. Alternative SB-8 is preferred if less than 60% weight is given to the NED criteria, with the three life safety criteria given moderately higher weights than the environmental effects and floodplain criteria.

Method C (Pair-wise Comparison) provided the clearest comparison of the alternatives and of the trade-offs among them in terms of beneficial and adverse effects. This method focused on whether a deviation from recommendation of the NED Plan is warranted. The analysis found that if the additional life safety/critical infrastructure benefits of Alternative SB-8 are considered to outweigh the higher costs, reduction in net NED benefits, increased environmental footprint, and increase in potentially developable floodplain, then Alternative SB-8 would provide greater net monetary and non-monetary benefits than the NED Plan, Alternative SB-7. In order for Alternative SB-6 to be recommended rather than the NED Plan, a very high value would have to be placed on the life safety/critical infrastructure criteria to offset the disadvantages of Alternative SB-6, which are its much higher costs, lower net NED benefits, and significantly greater increases in the environmental footprint and potentially developable floodplain area.

In conclusion, the combined results of the three methods of multi-objective analysis indicate that consideration given to the metric for the potentially developable floodplain area is a key factor in identifying the recommended Tentatively Selected Plan (TSP).

A determination must be made as to whether the increases in potentially developable floodplain area due to Alternatives SB-6, SB-7, and SB-8 are acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. In making that determination, it is important to remember that the floodplain metric used in this analysis is a simple index based on physical parameters. The floodplain metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. The metric also does not account for existing land use regulations and easements within the Basin. Those aspects should be considered in conjunction with the floodplain metric. The floodplain metric should be used to identify the specific locations where increases in the potentially developable floodplain area could occur. That information can be used to further assess the residual risks, including residual flood depths, associated with different alternative plans.

A second key factor in identifying the recommended TSP is the relative importance placed on the three life safety criteria (population at risk, evacuation, and critical infrastructure), relative to the importance placed on maximizing net NED benefits and minimizing the environmental effects footprint and potentially developable floodplain area. The NED plan, Alternative SB-7, would be the best choice for the TSP if all of the non-NED criteria are given equal importance and less than 40% combined weight, based on Method B. If the non-NED criteria are given equal importance and more than 40% combined weight, than Alternative SB-8 would be the preferred plan. If very high importance is given maximizing life safety, compared to all other criteria, then the most comprehensive and costly plan, Alternative SB-6 would be the favored choice for the TSP.